Załącznik Nr 5 do Zarz. Nr 33/11/12

(faculty stamp)   **COURSE DESCRIPTION**

1. Course title: Fuzzy Evolutionary Hybrid Inference Systems	**2. Course code:** FEHIS

3. Validity of course description: 2017/2018

4. Level of studies: ~~BA, BSc programme~~ / MA,MSc programme ~~lub 1st cycle / 2nd cycle of higher education~~

5. Mode of studies: intramural studies ~~/ extramural studies~~

6. Field of study: CEIE - Interdisciplinary Studies: Automatic Control and Robotics, Electronics and Telecommunications, Computer Science	(FACULTY SYMBOL) RAU2

7. Profile of studies: comprehensive practical

8. Programme: all

9. Semester: 2

10. Faculty teaching the course: Faculty of Automatic Control, Electronics and Computer Science

11. Course instructor: Ph.D. Eng. Piotr Czekalski

12. Course classification: common courses

13. Course status: ~~compulsory~~ /elective

14. Language of instruction: English

15. Pre-requisite qualifications:

Programming skills in at least one of the following languages: C#, Java, Matlab (semantic programming) are essential for the laboratory;

Understanding of parallel programming issues and problems is suggested;

Also suggested (however not necessary) general knowledge on Genetic Algorithms and Fuzzy Sets;

16. Course objectives: The main goal is to present audience a modern approach to the AI: automated learning systems. To obtain this goal, an in-depth review of the fuzzy inference systems, genetic algorithms and evolutionary strategies (may include neural networks as well) is presented as cooperating to constitute a hybrid approach to the machine learning. This course brings various opportunities to find valuable M.Sc. thesis' themes.

17. Description of learning outcomes:

Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
1.	The student has in-depth knowledge on mathematical, analytical and algorithmic modelling of complex systems for various classes of numeric optimisation problems (both linear and non-linear) with means of heuristic approach. Ma pogłębioną wiedzę w zakresie matematycznych, analitycznych oraz algorytmicznych metod rozwiązywania różnych klas problemów optymalizacyjnych oraz budowy modeli i metod modelowania złożonych układów.	CL	Lecture and laboratory	T2A_W02
2.	The student has advanced knowledge on inference methods and their application in analysis and implementation of the algorithms.	CL	Lecture and laboratory	T2A_W01, T2A_W03, T2A_W04
3.	The student is capable of defining optimisation and simulation model for simple and complex systems and can optimise it for software and hardware implementation.	LE	Laboratory	T2A_W09

18. Teaching modes and hours

Lecture / BA /MA Seminar / Class / Project / Laboratory:

30 / 0 / 0 / 0 / 0 / 15

19. Syllabus description:

<u>Lecture.</u>
The lecture is performed in double intensity through the first half of the semester.

1

The first part of the lecture covers theoretical aspects on the popular models of the fuzzy inference systems, evolutionary strategies and genetic algorithms. The second part of the lecture present practical aspects of joining the presented methods to constitute machine learning (self-extracting / knowledge discovering) hybid systems.

Presentation Plan:

1. Fuzzy sets theory review.
2. Fuzzy inference systems.
   2.1. Fuzzy relations and linguistics variables.
   2.2. If-then rules
      2.2.1. Fuzzy rules database and inference.
   2.3. Mamdani-Assilian FIS model
   2.4. Takagi-Sugeno-Kang FIS model
   2.5. Czogała-Łęski FIS with parameterized consequents.
3. Evolutionary techniques
   3.1. A mathematical model of mother nature.
   3.2. Genetic algorithms review.
      3.2.1. Introduction.
      3.2.2. Members coding/modeling.
      3.2.3. Fitness function and border conditions.
      3.2.4. Genetic operators.
      3.2.5. Reproduction and stop conditions.
   3.3. Evolutionary computing.
      3.3.1. Introduction.
      3.3.2. Evolutionary strategies.
      3.3.3. Fitness function and border conditions.
      3.3.4. Members coding/modeling.
      3.3.5. Evolutionary operators.
   3.4. What is a difference between GA and EA?
4. Fuzzy-evolutionary techniques.
   4.1. Fuzzy database learning models review.
      4.1.1. Michigan approach.
      4.1.2. Pittsburgh approach.
      4.1.3. Iterative learning.
   4.2. Data mining for fuzzy rules – system learning.
      4.2.1. Three stage Mamdani-Assilian FIS fuzzy rules extraction.
      4.2.2. Two-stage Takagi-Sugeno-Kang FIS fuzzy rules extraction.
      4.2.3. Fuzzy Inference System with parameterize d consequent fuzzy rules extraction.
5. Experiment design.
   5.1. Training data set and validation data set.

<u>Labs.</u>
   1. Labs on with the fuzzy inference systems using Matlab Fuzzy Logic Toolbox and C++ / C# libraries (as choosen by students and their programming experience).
   2. Labs on implementing various models of the hybrid inference systems using C++ / C# or Matlab.
   3. Code optimization with respect to the parallel processing (multithreaded / nVidia cuda).

20. Examination: none

21. Primary sources:

1. Zadeh, L. A., Fuzzy Sets. Information and Control, 8, 1965, 338-353.
2. Czogała, E., Łęski, J., A New Fuzzy Inference System with Moving Consequents in If-then Rules. Application to Pattern Recognition. Bulletin of the Polish Academy of Science, 45 (4), 1996, 643-655.
3. Czogała, E., Łęski, J., Fuzzy and Neuro-fuzzy Intelligent Systems. Physica-Verlag, A Springer-Verlag Company, Heidelberg, New York, 1999 – <u>similar as position 5 but in english.</u>
4. Łęski, J., Czogała, E., A New Artifficial Neural Network Based Fuzzy Inference System with Moving Consequents in If-then Rules and Selected Applications. Fuzzy Sets and Systems, 108, 1999, 289-297.
5. Łęski, J., Systemy neuronowo-rozmyte. WNT, 2008 – <u>similar as position 3 but in Polish.</u>

22. Secondary sources:

1. Alba, E., Cotta, C., Troya, J.M., Evolutionary Design of Fuzzy Logic Controllers Using Strongly-typed GP. Mathware Soft Comput., 6 (1), 1999, 109–124.

2. Alcalá, R., Benitez, J. M., Casíllas, J., Cordón, O., Pérez, R., Fuzzy Control of HVAC Systems Optimized by Genetic Algorithms. Applied Intelligence, 18, 2003, 155-177.

3. Alcalá, R., Casillas, J., Cordón, O., Herrera, F., Linguistic Modeling with Weighted Double-Consequent Fuzzy Rules Based on Cooperative Coevolutionary Learning. Raport nr DECSAI-010114, Wydział Informatyki i Sztucznej Inteligencji, University of Granada, 2001.

4. Angelov, P. P., Evolving Rule-Based Models. A Tool for Design of Flexible Adaptive Systems. Physica-Verlag, Wurzburg, 2002.

5. Babuska, R., Fuzzy Modeling for Control. Kluwer Academic Press, Dordrecht, 1998.

6. Baldwin, J. F., A New Approach to Approximate Reasoning Using a Fuzzy Logic. Fuzzy Sets and Systems, 2, 1979, 309-325.

7. Baldwin, J. F., Guild, N. C. F., Feasible Algorithms For Approximate Reasoning Using Fuzzy Logic. Fuzzy Sets and Systems, 3, 1980, 225-251.

8. Baldwin, J. F., Guild, N. C. F., Comparison of Fuzzy Sets on the Same Decision Space. Fuzzy Sets and Systems, 2, 1979, 213-231.

9. Baldwin, J. F., Pilsworth, B., W., Axiomatic Approach to Implication for Approximate Reasoning with Fuzzy Logic. Fuzzy Sets and Systems, 3, 1980, 193-219.

10. Baron, L., Achiche, S., Balazinski, M., Fuzzy Decision Support System Knowledge Base Generation Using a GeneticAlgorithm. International Journal of Approximate Reasoning, 28 (1), 2001, 125–148.

11. Bertoni, A., Dorigo, M., Implicit Parallelism in Genetic Algorithms. Artificial Intelligence, 61, 1993, 308-314.

12. Bethke, A. D., Genetic Algorithms as Function Optimizers. Rozprawa doktorska, Uniwersytet Michigan, 1981.

13. Bezdek, J. C., Pattern Recognition with Fuzzy Objective Function Algorithms. Plenum Press, New York, 1981.

14. Blake, C., Merz, C. J., UCI machine learning repository. Materiały on-line w sieci Internet: http://www.ics.uci.edu/~mlearn/MLRepository.html .

15. Bonari, A., Evolutionary Learning of Fuzzy Rules: Competition and Cooperation. W: W. Pedrycz Fuzzy Modelling: Paradigms and Practice, Kluwer Academic Press, Norwell, 1996, 265–284.

16. Bonissone, P. P., Khedkar P. S., Chen, Y., Genetic Algorithms for Automated Tuning of Fuzzy Constollers: A Transportation Application. W: Proc. of the 5th IEEE International Conference on Fuzzy Systems, New Orleans, USA, 1996, 674-680.

17. Booch, G., Jacobson, I., Rumbaugh, J., OMG Unified Modeling Language Specification, Version 1.4. Materiały on-line w sieci Internet: http://www.omg.org, 2001.

18. Borwein, J. M., Borwein, P. B., Pi & the AGM: A Study in Analytic Number Theory and Computational Complexity. Wiley, New York, 1987.

19. Box, G. E. P., Jenkins, G. M., Time Series Analysis. Forecasting and Control. Holden-Day, San Francisco, 1976.

20. Brindle, A., Genetic Algorithms for Function Optimization. Rozprawa doktorska, University of Alberta, 1981.

21. Buckles, B.P., Petry, F.E., Prabhu, D., George, R., Srikanth, R., Fuzzy Clustering with Genetic Search. W: Proc. of the 1st IEEE Conference on Evolutionary Computation, Orlando, USA, 1994, 46–50.

22. Bullen, P. S., Handbook of Means and Their Inequalities. Kluwer Academic Publishers, Dordrecht, Netherlands, 2003.

23. Carse, B., Fogarty, T.C., Munro, A. Evolving Fuzzy Rule Based Controllers Using Genetic Algorithms. Fuzzy Sets and Systems, 80, 1996, 273–294.

24. Casillas, J., Cordón, O., Del Jesus, M. J., Herrera, F., Genetic Feature Selection in a Fuzzy Rule-Based Classification System Learning Process for High Dimensional Problems. Inform. Sci., 136, 2001, 169–191.

25. Chen, J. Q., Xi, Y., G., Zhang, Z., J., A Clustering Algorithm for Fuzzy Model Identification. Fuzzy Sets and Systems, 98, 1998, 319-329.

26. Cheong, F., Lai, R., Constraining the Optimization of a Fuzzy Logic Controller Using an Enhanced Genetic Algorithm. IEEE Trans. Systems Man Cybernet., B 30, 2000, 31–46.

27. Chi, Z., Yan, H., Pham T., Fuzzy Algorithms: With Applications to Image Processing and Pattern Recognition. World Scientific, Singapore, 1996.

28. Cho, K. B., Wang., B. H.,Radial Basis Function Based Adaptive Fuzzy Systems and Their Applications to Systems Identification and Prediction. Fuzzy Sets and Systems, 83, 1996, 325-339.

29. Chien, B.-C., Lin, J. Y., Hong, T.-P., Learning Discriminant Functions with Fuzzy Attributes for Classification Using Genetic Programming. Expert Systems Appl., 23 (1), 2002, 31–37.

30. Chiu, S. L., Selecting Input Variables for Fuzzy Models. Journal of Intelligant & Fuzzy Systems, 4 (4), 1996, 243-256.

31. Cordón, O., Gomide, F., Herrera, F., Hoffmann, F., Magdalena, L., Ten Years of Genetic Fuzzy Systems: Current Framework and New Trends. Fuzzy Sets and Systems, 141, 2004, 5-31.

32. Cordón, O., Herrera, F., A Proposal for Improving the Accuracy of Linguistic Modeling. IEEE Trans. Fuzzy Systems, 8 (3), 2000, 335–344.

33. Cordón, O., Herrera, F., Identification of Linguistic Fuzzy Models by Means of Genetic Algorithms. Springer-Verlag, 1997, 215-250.

34. Cordón, O., Herrera, F., Hoffmann, F., Magdalena, L., Genetic Fuzzy Systems-Evolutionary Tuning and Learning of Fuzzy Knowledge Bases. World Scientific, Singapore, 2001.

35. Cordón, O., Herrera, F., A Three-stage Evolutionary Process for Learning Descriptive and Approximative Fuzzy Logic Controller Knowledge Bases from Examples. International Journal of Approximate Reasoning, 17 (4), 1997, 369-407.

36. Cordón, O., Herrera, F., A Two-stage Evolutionary Process for Designing TSK Fuzzy Rule-based Systems. IEEE Trans. Systems Man Cybernet., 29 (6), 1999, 703–715.

37. Cordón, O., Herrera, F., Hybridizing Genetic Algorithms with Sharing Scheme and Evolution Strategies for Designing Approximate Fuzzy Rule-based Systems. Fuzzy Sets and Systems, 118 (2), 2001, 235–255.

38. Cordón, O., Herrera, F, Magdalena, L., Villar, P., A Genetic Learning Process for the Scaling Factors, Granularity and Contexts of the Fuzzy Rule-Based System Data Base. Inform. Sci., 136 (1–4), 2001, 85–107.

39. Cordón, O., Herrera, F, Villar, P., Generating the Knowledge Base of a Fuzzy Rule-based System by the Genetic Learning of the Data Base. IEEE Trans. Fuzzy Systems, 9 (4), 2001, 667–674.

40. Cordón, O., Herrera, F, Zwir, I., Linguistic Modeling by Hierarchical Systems of Linguistic Rules. IEEE Trans. Fuzzy Systems, 10 (1), 2002, 2–20.

41. Cordón, O., Del Jesús, M. J., Herrera, F., Lozano, M., MOGUL: a Methodology to Obtain Genetic Fuzzy Rule-based Systems Under the Iterative Rule Learning Approach. International Journal of Intelligent Systems, 14 (11), 1999, 1123–1153.

42. Czabański, R., Automatyczne wyznaczanie reguł rozmytych jeżeli-to na podstawie danych numerycznych. Rozprawa doktorska, Politechnika Śląska w Gliwicach, 2002.

43. Czogała, E., Fodor, J., Łęski, J., On Modeling Destructive Logical Type Systems Using Fodor Fuzzy Implication. Proc. 5th European Congres Intelligent Techniques and Soft Computing EUFIT, Aachen, 1997, 340-343.

44. Czogała, E., Łęski, J., On Equivalence of Approximate Reasoning Results Using Different Interpretations of Fuzzy If-then Rules. Fuzzy Sets and Systems, 117, 2001, 279-296.

45. Czogała, E., Pedrycz W., Elementy i metody teorii zbiorów rozmytych. Wydawnictwo Politechniki Śląskiej, Gliwice, 1983.

46.   Damousis, L. G., Dokopoulos, P., A Fuzzy Expert System for the Forecasting of Wind Speed and Power Generation in Wind Farms. W: Proc. of the 22nd Interantional Conference on Power Industry Computer Applications, 2001, Sydney, 63-69.

47.   Davis, L., Adapting Operator Probabilities in Genetic Algorithms. W: Proc. of the 3rd International Conference on Genetic Algorithms, 1989, 61-69.

48.   De Jong, K. A., An Analysis of the Behavior of a Class of Genetic Adaptive Systems. Rozprawa doktorska, University of Michigan, 1975.

49.   De Jong, K. A., Learning with Genetic Algorithms: an Overview. Mach. Learning, 3 (3), 1988, 121–138.

50.   Dianati, M., Song, I., Treiber, M., An Introduction to Genetic Algorithms and Evolution Strategies. Materiały własne University of Waterloo, Ontario, Canada, 2002.

51.   Driankov, D., Hellendoorn, H., Reinfrank, M., Wprowadzenie do sterowania rozmytego. Wydawnictwa Naukowo-Techniczne, Warszawa, 1996.

52.   Eiben, A. E., Aarts, E. H. L., Van Hee, K. M., Global Convergence of Genetic Algorithms: An Infinite Markov Chain Analysis. W: Proc. of the 1st International Conference on Parallel Problem Solving from Nature, Springer, Berlin, 1991, 4-12.

53.   Fodor, J. C., Contrapositive Symmetry of Fuzzy Implications. Fuzzy Sets and Systems, 69, 1995, 141-156.

54.   Fodor, J. C., On FuzzyImplication Operators. Fuzzy Sets and Systems, 42, 1991, 293-300.

55.   Fodor, J. C., Fuzzy Implications. Proc. of the International Conference on Soft and Intelligent Computing, Budapest, 1996, 91-98.

56.   Fodor, J. C., Fuzzy Preference Modeling and Multicriteria Decision Support. Kluwer Academic, Dordrecht, 1994.

57.   Fogel, D. B., Evolving Artificial Intelligence. Rozprawa doktorska, University of California, San Diego, 1992.

58.   Fogel, D. B., Evolutionary Computation: Toward a New Philosophy of Machine Intelligence. IEEE Press, Piscataway, New Jersey, 1995.

59.   Fogel, D. B., Atmar, W., Hierarchic Methods of Evolutionary Programming. W: Proc. of the 1st International Conference on Evolutionary Programming, Evolution Programming Society, Los Angeles, 1992, 175-182.

60.   Fogel, D. B., Sebald, A. V., Steps Toward Controlling Blood Pressure During Surgery using Evolutionary Programming. W: Proc. of 4th Annual Conference on Evolutionary Programming, MIT Press, 1995, 69-82.

61.   Fogel, L. J., Owens, A. J., Walsh, M. J.,: Artificial Intelligence Through Simulated Evolution. John Wiley & Sons, 1966.

62.   Fowler, M., Scott, K., UML w kropelce. LTP, Warszawa, 2002.

63.   Fuller, R., Introduction to Neuro-Fuzzy Systems. Physica-Verlag, Wurzburg, 1999.

64.   Geyer-Schulz, A. Fuzzy Rule-Based Expert Systems and Genetic Machine Learning. Physica-Verlag, Heidelberg, 1995.

65.   Goldberg, D. E., Korb, B., Deb, K., Messy Genetic Algorithms: Motivation, Analysis, and First Results. Complex Systems, 3, 1989, 493-530.

66.   Goldberg, D. E., Segrest, P., Finite Markov Chain Analysis of Genetic Algorithms. W: Proc. of the 2nd International Conference on Genetic Algorithms, 1993, 1-8.

67.   González, A., Pérez, R., SLAVE: a Genetic Learning System Based on an Iterative Approach. IEEE Trans. Fuzzy Systems, 7 (2), 1999, 176–191.

68.   González, A., Pérez, R., Selection of Relevant Features in a Fuzzy Genetic Learning Algorithm. IEEE Trans. System Man Cybernet., B 31 (3), 2001, 417–425.

69.   Gómez-Skarmeta, A.F., Jiménez, F., Fuzzy Modeling with Hybrid Systems. Fuzzy Sets and Systems, 104, 1999, 199–208.

70.   Hall, L.O., Bezdek, J.C., Boggavarapu, S., Bensaid, A., Genetic Fuzzy Clustering. W: Proc. NAFIPS'94, San Antonio, 1994, 411–415.

71.   Harel, D., Rzecz o istocie informatyki. Algorytmika. Wydawnictwa Naukowo-Techniczne, Warszawa, 2000.

72.   Herrera, F., Lozano, M., Verdegay, J. L., A Learning Process for Fuzzy Control Rules Using Genetic Algorithms. Fuzzy Sets and Systems, 100, 1998, 143-158.

73.   Herrera, F., Lozano, M., Verdegay, J. L., Generating Fuzzy Rules from Examples using Genetic Algorithms. Fuzzy Logic and Soft Computing, World Scientific, 1995.

74.   Herrera, F., Lozano, M., Verdegay, J. L., Tuning Fuzzy Logic Controllers by Genetic Algorithms. International Journal of Approximate Reasoning, 12, 1995, 299-315.

75.   Herrera, F., Verdegay, J. L., Genetic Algorithms and Soft Computing. Physica-Verlag, Wurzburg, 1996.

76.   Hoffmann, F., Nelles, O., Genetic Programming for Model Selection of TSK-Fuzzy Systems. Inform. Sci., 136 (1–4), 2001, 7–28.

77.   Hoffmann, F., Pfister, G., Evolutionary Design of a Fuzzy Knowledge Base for a Mobile Robot. International Journal of Approximate Reasoning 17 (4), 1997, 447–469.

78.   Hoffmeister, F., Bäck, T., Genetic Algorithms and Evolution Strategies: Similarities and Differences. W: Proc. of the 1th International Conference on Parallel Problem Solving from Nature, Springer, Berlin, 1991, 455-469.

79.   Holland, J. H., Adaptation in Natural and Artificial Systems. University of Michigan Press, Ann Arbor, 1975.

80.   Holland, J. H., Reitman J. S., Cognitive Systems Based on Adaptive Algorithms. W: Waterman D. A., Hayes-Roth, F., Pattern-Directed Inference Systems. Academic Press, New York, 1978, 313-329.

81.   Hong, T.-P., Chen, J.-B., Finding Relevant Attributes and Membership Functions, Fuzzy Sets and Systems, 103 (3), 1999, 389–404.

82.   Hwang, H. S., Control Strategy for Optimal Compromise Between Trip Time and Energy Consumption in a High-speed Railway. IEEE Trans. Systems, Man and Cybernetics, 28 (6), 1998, 791-802.

83.   Ishibuchi, H., Fujioka, R., Tanaka, H., Neural Network That Learn From Fuzzy If-then Rules. IEEE Trans. Fuzzy Systems, 1(2), 1993, 85-97.

84.   Ishibuchi, H., Murata, T., Türksen, I. B., Single-objective and Two-objective Genetic Algorithms for Selecting Linguistic Rules for Pattern Classification Problems. Fuzzy Sets and Systems, 89, 1997, 135–150.

85.   Ishibuchi, H., Nakashima, T., Effect of Rule Weights in Fuzzy Rule-based Classification Systems. IEEE Trans. Fuzzy Systems, 9 (4), 2001, 506–515.

86.   Ishibuchi, H., Nakashima, T., Murata, T., Performance evaluation of fuzzy classifier systems for multidimensional pattern classification problems. IEEE Trans. Systems, Man and Cybernetics, 29, 1999, 601–618.

87.   Ishibuchi, H., Nozaki, K., Yamamoto, N., Tanaka, H., Selecting Fuzzy If-then Rules for Classification Problems Using Genetic Algorithms. IEEE Trans. Fuzzy Systems, 3 (3), 1995, 260–270.

88.   Jang, J.-S. R., Self-learning Fuzzy Controllers Based on Temporal Back Propagation. IEEE Trans. Neural Networks, 3 (5), 1992, 714-723.

89.   Jang, J.-S. R., Sun, C.-T., Functional Equivalence Between Radial Basis Function Networks and Fuzzy Inference Systems. IEEE Trans. Neural Networks, 4 (1), 1993, 156-159.

90.   Jang, J.-S. R., Sun, C.-T., Neuro-fuzzy modeling and control. Proc of IEEE, 83 (3), 1995, 378-406.

91.   Jang, J.-S. R., Sun, C.-T., Mizutani, E., Neuro-Fuzzy and Soft Computing. Prentice-Hall, Englewood Cliffs, 1997.

92.   Juuso, R., Koivisto, H., Optimised Substractive Clustering for Neuro-Fuzzy Models. 3rd WSES Int. Conference on Fuzzy Systems (FSFS'02), Interlaken, 2002.

93.   Kim, E., Park, M., Ji, S., A new approach to fuzzy modeling. IEEE Trans. Fuzzy Systems, 5 (3), 1997, 328-337.

94.   Kirkpatrick, S., Gelatt, C. D., Vecchi, M. P., Optimization by Simulated Annealing. Science, 220 (4598), 1983, 671-680.

95.   Kosko, B., Fuzzy associative memories. W: Kandel, A., Fuzzy expert systems, Addison-Wesley, 1987.

96.   Koza, J. R., Genetic Programming: A Paradigm for Genetically Breeding Populations of Computer Programs to Solve Problems. Raport nr STAN-CS-90-134, Stanford University, 1990.

97.   Koza, J. R., Evolving a Computer Program to Generate Random Numbers Using Genetic Programming Paradigm. W: Proc. of the 4th International Conference of Genetic Algorithms, Morgan Kaufmann Publishers, 1991, 37-44.

98.   Koza, J. R., Genetic Programming. MIT Press, Cambridge, 1992.

99.   Koza, J. R., Genetic Programming – 2. MIT Press, Cambridge, 1994.

100.   Lee, H.-M., Chen, C.-M., Chen, J.-M., Jou, Y.-L., An Efficient Fuzzy Classifier with Feature Selection Based on Fuzzy Entropy. IEEE Trans. Systems Man Cybernet., B 31 (3), 2001, 426–432.

101.   Lee, M. A., Takagi, H., Integrating Design Stages of Fuzzy Systems Using Genetic Algorithms. W: Proc. of the 2nd IEEE International Conference on Fuzzy Systems, San Francisco, 1993, 613-617.

102.   Lin, Y. Cunningham, H., A., A new approach to fuzzy-neural modeling. IEEE Trans. Fuzzy Systems, 3, 1995, 190-197.

103.   Liska, J., Melsheimer, S. S., Complete Design of Fuzzy Logic System Using Genetic Algorithms. W: Proc. of the 3rd IEEE International Conference on Fuzzy Systems, 2, Orlando, 1994, 1377-1382.

104.   Łęski, J., Materiały on-line w sieci Internet: http://zeb.iele.polsl.gliwice.pl .

105.   Łęski, J., TSK-Fuzzy Modeling Based on □-Insensitive Learning. IEEE Trans. Fuzzy Systems, w druku.

106.   Magdalena, L., Monasterio, F., A Fuzzy Logic Controller with Learning Through the Evolution of its Knowledge Base. International Journal of Approximate Reasoning, 16 (3-4), 1997, 335-358.

107.   Mamdani, E. H., Assilian, S., An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller. International Journal of Man-Machine Studies, 7 (1), 1975, 1-13.

108.   MathWorks, MATLAB Classes and Objects. Materiały on-line w sieci Internet: http://www.mathworks.com/access/helpdesk/help/techdoc/matlab_prog/matlab_prog.html

109.   McCulloch, W. S., Pitts, W., A Logical Calculus of the Ideas Immanent in Nervous Activity. Bulletin of Mathematical Biophysics, 5, 1943, 115-133.

110.   Michalewicz, Z., Janikow, C., Handling Constraints in Genetic Algorithms. W: Proc. of the 4th International Conference on Genetic Algorithms, 1991, 151-157.

111.   Michalewicz, Z., Janikow, C., GENOCOP: A Genetic Algorithm for Numerical Optimization Problems with Linear Constraints. Communications of the ACM, 39 (12es), 1996, 175-201.

112.   Michalewicz, Z., Fogel, D. B., How to Solve It: Modern Heuristic. Springer-Verlag, 1999.

113.   Mitra, S., Pal, S. K., Fuzzy Multi-layer Perceptron, Inferencing and Rule Generation. IEEE Trans. Neural Networks, 6, 1995, 51-63.

114.   Muller, R. J., Bazy danych język UML w modelowaniu danych. MIKOM, Warszawa, 2000.

115.   Nascimiento, S., Moura-Pires, F., A Genetic Approach for Fuzzy Clustering with a Validity Measure Function. W: Proc. of the 2nd International Conference on Intelligent Data Analysis, Springer-Verlag, Berlin, 1997, 325–335.

116.   Nauck, D., Klawoon, F., Kruse, R., Foundations of Neuro-Fuzzy Systems. John Wiley & Sons, New York, 1997.

117.   Papadakis, S.E., Theocharis, J.B., A GA-based Fuzzy Modeling Approach for Generating TSK Models. Fuzzy Sets and Systems, 131 (1), 2002, 121–152.

118.   Papoulis, A., Probability, Random Variables, and Stochastic Processes. McGraw-Hill, New York, 1984.

119.   Park, D., Kandel, A., Langholz, G.., Genetic-based New Fuzzy Reasoning Models with Application to Fuzzy Control. IEEE Trans. Systems Man Cybernet., 24 (1), 1994, 39–47.

120.   Parodi, A., Bonelli, P., A New Approach to Fuzzy Classifier Systems, W: Proceedings of 5th International Conference on Genetic Algorithms, Morgan Kaufmann, Los Altos, 1993, 223–230.

121.   Pedersen, J. T., Moult, J., Genetic Algorithms for Protein Structure Prediction. Current Opinion in Structural Biology, 6, 1996, 227-231.

122.   Pedrycz, W., An Identification Algorithm in Fuzzy Relational Systems. Fuzzy Sets and Systems, 13, 1984, 153-167.

123.   Pedrycz, W., Fuzzy Evolutionary Computation. Kluwer Academic Publishers, Dordrecht, 1997.

124.   Pedrycz, W., Fuzzy Modelling: Paradigms and Practices. Kluwer Academic Publishers, Boston, 1996.

125.   Pedrycz, W., Identification in fuzzy systems. IEEE Trans. Systems, Man and Cybernetics, 14, 1984, 361-366.

126.   Peňa-Reyes, C.A., Sipper, M., Fuzzy CoCo: A Cooperative Coevolutionary Approach to Fuzzy Modeling. IEEE Trans. Fuzzy Systems, 9 (5), 2001, 727–737.

127.   Pham, D. T., Karaboga, D., Optimum Design of Fuzzy Logic Controllers Using Genetic Algorithms. Journal of Systems Engineering, 1 (2), 1991, 114–118.

128.   Qin, Z., Lawry, J., Randon, N., Prediction and Query Evaluation Using Linguistic Decision Trees. International Journal of Approximate Reasoning, złożone w redakcji, 2004.

129.   Randon, N. J., Fuzzy and Random Set Based Induction Algorithms. Rozprawa doktorska, Dept. Of Engineering Mathematics, University of Bristol, 2004.

130.   Rechenberg I.: Evolutionsstrategie: Optimierung Technischer Systeme nach Prinzipien der Biologischen Evolution. Frommann-Holzboog, Stuttgart, 1973.

131.   Rojas, I., Gonzalez, J., Pomares, H., Rojas, F.J., Fernández, F.J., Prieto, A., Multidimensional and Multideme Genetic Algorithms for the Construction of Fuzzy Systems. International Journal of Approximate Reasoning, 26 (3), 2001, 179–210.

132.   Rose, K., Deterministic Annealing, Clustering and Optimization. Praca doktorska, California Institute of Technology, Pasadena, 1991.

133.   Rose, K., Deterministic Annealing for Clustering, Compression, Classification, Regression, and Related Optimization Problems. Proc. IEEE, 86 (11), 1998, 2210-2239.

134.   Roubos, H., Setnes, M., Compact and Transparent Fuzzy Models Through Iterative Complexity Reduction. IEEE Trans. Fuzzy Systems, 9 (4), 2001, 515–524.

135.   Rudolph, G., Convergence Analysis of Canonical Genetic Algorithms. IEEE Trans. Neural Networks, wydanie specjalne poświęcone obliczeniom ewolucyjnym, 5 (1), 1994, 96-101.

136.   Sánchez, L., Corrales, J.A., Niching Scheme for Steady State GA-P and its Application to Fuzzy Rule Base Classifiers Induction. Mathware Soft Comput., 7 (2–3), 2000, 337–350.

137.   Sánchez, L., Couso, I., Corrales, J.A., Combining GP Operators with SA Search to Evolve Fuzzy Rule-Based Classifiers. Inform. Sci., 136 (1–4), 2001, 175–191.

138.   Sanchez, E., Shibata, T., Zadeh, L., Genetic Algorithms and Fuzzy Logic Systems. Soft Computing Perspectives. World Scientific, Singapore, 1997.

139.   Satyadas, A., KrishnaKumar, K., EMF-based Controllers for Space Attitude Control: Applications and Analysis. W: Genetic Algorithms and Soft Computing, Physica-Verlag, Wurzburg, 1996, 152-171.

140.   Schuster, H. G., Deterministic chaos. Wydanie drugie, VCH Verlagsgesellschaft, New York, 1988.

141.   Schwefel, H. P., Numerical Optimization for Computer Models. John Wiley, Chichester, 1981.

142.   Silipo, R., Berthold, M. R., Input Features' Impact on Fuzzy Decision Processes. IEEE Trans. Systems, Man Cybernetics, B 30 (6), 2000, 821–834.

143.   Smith, S. F., A Learning System Based on Genetic Adaptive Algorithms. Rozprawa doktorska, Wydział Informatyki uniwersytetu w Pittsburgh, 1980.

144. Sugeno, M., Kang, G., T., Structure Identification of Fuzzy Model. Fuzzy Sets and Systems, 28, 1988, 15-33.
145. Sugeno, M., Yasukawa, T., A Fuzzy-Logic Based Approach to Qualitative Modeling. IEEE Trans. Fuzzy Systems, 1 (1), 1993, 7-31.
146. Szałas, A., Michalewicz, Z., Contractive Mapping Genetic Algorithms and Their Convergence. Raport nr 006-1993, The University of North Carolina, Charlotte, 1993.
147. Takagi, T., Sugeno, M., Fuzzy Identification of Systems and its Application to Modeling and Control. IEEE Trans. Systems, Man and Cybernetics, 15 (1), 1985, 116-132.
148. Thrift, P., Fuzzy Logic Synthesis with Genetic Algorithms. W: Proc. of the 4th International Conference on Genetic Algorithms, Morgan Kaufmann, Los Altos, 1991, 509–513.
149. Tong, R., M., The Evaluation of Fuzzy Models Derived from Experimental Data. Fuzzy Sets and Systems, 4, 1980, 1-12.
150. Valenzuela-Rendón, M., The Fuzzy Classifier System: Motivations and First Results. W: Proc. of the 1st International Conference on Parallel Problem Solving from Nature, Springer-Verlag, Berlin, 1991, 330–334.
151. Van Le, T., Evolutionary Fuzzy Clustering. W: Proc. of the 2nd IEEE Conference on Evolutionary Computation, 2, Perth, Australia, 1995, 753–758.
152. Velasco, J.R., Genetic-Based On-Line Learning for Fuzzy Process Control. International Journal of Intelligent System, 13 (10–11), 1998, 891–903.
153. Venturini, G., SIA: A Supervised Inductive Algorithm with Genetic Search for Learning Attribute Based Concepts. W: Proc. European Conference on Machine Learning, Vienna, 1993, 280-296.
154. Wang, C. H., Hong, T. P., Tseng, S. S., Integrating Fuzzy Knowledge by Genetic Algorithms. IEEE Trans. Evolutionary Computation, 2 (4), 1998, 138–149.
155. Wang, L., Langari, R., Building Sugent-type Models Using Fuzzy Discretization and Orthogonal Parameter Estimation Techniques. IEEE Trans. Fuzzy Systems, 3, 1995, 454-458.
156. Weigend, A. S., Huberman, B. A., Rumelhart, D. E., Predicting the Future: A Connectionist Approach. International Journal of Neural Systems, 1, 1990, 193-209.
157. Weisstein, E. W., Banach Fixed Point Theorem. W: MathWorld - A Wolfram Web Resource, materiały on-line w sieci Internet: http://mathworld.wolfram.com/BanachFixedPointTheorem.html
158. Weisstein, E. W., Markov Chain. W: MathWorld - A Wolfram Web Resource, materiały on-line w sieci Internet: http://mathworld.wolfram.com/MarkovChain.html.
159. Weisstein, E. W., Normal Distribution. W: MathWorld - A Wolfram Web Resource, materiały on-line w sieci Internet: http://mathworld.wolfram.com/NormalDistribution.html
160. Wirth, N., Algorytmy + struktury danych = programy. Wydawnictwa Naukowo-Techniczne, Warszawa, 2001.
161. Xu, C., W., Lu, Y., Z., Fuzzy Modeling Identification and Self-Learining for Dynamic Systems. IEEE Trans. Systems, Man and Cybernetics, 17, 1987, 683-689.
162. Zadeh, L. A., Fuzzy Algorithms. Information and Control, 12, 1968, 94-102.
163. Zadeh, L. A., Towards a theory of fuzzy systems. W: Kalman, R.E., DeClaris, R.N., Aspects of Network and System Theory. Holt, Rinehart and Winston, New York, 1971, 469-490.
164. Zadeh, L. A., Outline of a New Approach to the Analysis of Complex Systems and Decision Processes. IEEE Trans. Systems, Man and Cybernetics, 3 (1), 1973, 28-44.
165. Zadeh, L. A., The Concept of a Linguistic Variable and Its Application to Approximate Reasoning. cz. 1, Inf. Science, 8, 199-249, 1975.
166. Zadeh, L. A., The Concept of a Linguistic Variable and Its Application to Approximate Reasoning. cz. 2, Inf. Science, 8, 301-357, 1975.
167. Zadeh, L. A., The Concept of a Linguistic Variable and Its Application to Approximate Reasoning. cz. 3, Inf. Science, 9, 43-80, 1975.
168. Zikidis, K., C., Vasilakos, A., V., ASAFES2: A Novel, Neuro-Fuzzy Architecture for Fuzzy Computing, Based on Functional Reasoning. Fuzzy Sets and Systems, 83, 1996, 63-68.

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/30
2	Classes	0/0
3	Laboratory	15/45
4	Project	/
5	BA/ MA Seminar	/
6	Other	/
	Total number of hours	45/75

24. Total hours: 120

25. Number of ECTS credits: 4

26. Number of ECTS credits allocated for contact hours: 2

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 2

26. Comments:

Lecture credit: presence is obligatory.

Laboratory: performing all exercises and documenting results, obtaining positive grade on each laboratory, presence during laboratory and active.

This subject usually brings various possibilities to extend laboratory work/projects into the M.Sc. thesis as job done here is classified as pure research.

Approved:

…………………………   ……………………………………………
(date, Instructor's signature)   (*date , the Director of the Faculty Unit signature)*

…………………………   ……………………………………………
(date, Instructor's signature)   (*date , the Director of the Faculty Unit signature)*