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| **類神經網路課程大綱 2019** | | | | | |
| **科目名稱** | 類神經網路：理論與實務  (BSE 5114) | **學分** | 3 | | |
| **上課時間** | 星期一 14：20~17：20 | **上課地點** | 農工九 | | |
| **任課老師** | 張斐章 教授 E-mail：[changfj@ntu.edu.tw](mailto:changfj@ntu.edu.tw) 研究室電話：33663452 | | | | |
| **課程助教** | 邱普運 <r07622031@ntu.edu.tw> 研究室電話：33663490 | | | | |
| **課程說明** | **機器學習**是近年發展最快速的AI議題之一，其中以**類神經網路(ANNs)**為主的深度學習技術結合巨量資料的處理與應用漸趨熱切，如何**快速有效地從資料中篩選、萃取、分類及解析出有用的資訊**，創造出高價值的服務，實為一大挑戰。類神經網路具有從環境中擷取資訊，自我學習，從而做出推論之能力，利用電腦的軟體來模擬生物神經系統的資訊處理方式，由人類專家解決問題的實際案例中學習，利用統計、分類、非線性函數的轉換及最佳化原理等，能有效地對大量且複雜之資訊進行統計分析、分類、判識、推估等。類神經網路可解決過去傳統的電腦資訊理論中一些難以突破的瓶頸，例如：生物醫農領域中之判識、分類或推論；工程、科學與資訊管理領域中之模擬與預測、最佳化管理、非線性系統識別、圖形和語音的辨識、自動控制駕駛、電腦遊戲、或者是處理邏輯上的問題等。本課程藉由深入淺出說明ANNs的相關理論與展示實際研究案例，很適合對ANNs基本原理具濃厚興趣 及/或 想運用類神經網路科技解決地球科學、生態環境、生物醫學、工程與工商管理領域相關問題之同學共同來研習。  **Artificial Neural networks** is one of the main constitutional intelligence, the set of biological inspired computing paradigms used to learn and establish baseline behavioral profiles for various entities based on big data. ANNs can play an important role in solving certain problems in science and engineering such as **forecasting, pattern recognition, optimization and identification of nonlinear systems** etc. This course will cover the basic components of building and applying prediction functions with an emphasis on practical applications. The course will provide basic grounding in concepts such as training and tests sets, overfitting, and error rates. The course will also introduce a range of machine learning algorithms including BPNN, RBFNN, SOM, RNN, CFNN, ANFIS as well as deep learning algorithms such as LSTM and CNN. The course is primarily intended for those individuals, who want to understand the underlying principles of artificial neural networks and want to be able to apply various neurocomputing techniques to solve problems in earth sciences, business administration, ecological environment, biomedical, and engineering. | | | | |
| **教科書與**  **主要參考書籍** | Textbook:  張斐章、張麗秋，「類神經網路導論：原理與應用(第二版)(CD Inside)」，滄海書局，2015年。  References:   1. Simon Haykin; Neural Networks – A comprehensive foundation, 3nd Edition, 2009. 2. 類神經網路相關期刊論文導讀 ( <https://www.researchgate.net/profile/Fi-John_Chang/stats> ) | | | | |
| **軟體工具** | MATLAB、Neural Tool | | | | |
| **課程網址** | https://ceiba.ntu.edu.tw/ | | | | |
| **教學進度** | **主題** | | | **上課日期** | **備註** |
| 課程內容簡介、類神經網路簡述 | | | 9/9 |  |
| 生物神經網路與類神經網路、學習演算法、Neural Tool簡介 | | | 9/16 |  |
| 倒傳遞類神經網路(BPNN) | | | 9/23 | **作業一** |
| 倒傳遞類神經網路(BPNN) | | | 9/30 | 作業實習 |
| **教學進度** | 相關應用軟體的介紹(Ｍatlab & Ｐython) | | | 10/7 | 作業繳交 |
| 輻狀基底函數類神經網路(RBFNN) | | | 10/14 | **作業二** |
| 聚類演算法(Clustering) | | | 10/21 | 作業實習 |
| 自組性類神經網路(SOMNN) | | | 10/28 |  |
| 回饋式類神經網路(RNN)、長短期記憶體(LSTM) | | | 11/4 | 作業繳交 |
| 含外變數非線性自回歸模型(NARX) | | | 11/11 | **作業三** |
| 模糊集合與模糊邏輯系統 | | | 11/18 | 作業實習 |
| 反傳遞模糊類神經網路(CFNN) | | | 11/25 | 作業繳交 |
| 調適性網路模糊推論系統(ANFIS) | | | 12/02 |  |
| 期中考 | | | 12/09 |  |
| 深度學習(Deep learning) | | | 12/16 |  |
| 卷積類神經網路(CNN) | | | 12/23 |  |
| 專題演講-Big-data Mining & Applications | | | 12/30 |  |
| 期末考周 | | | 01/06 | 期末報告 |
| **成績計算方法** | 1.作業(35%) 2.期中考(35%) 3.期末報告(30%) | | | | |

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**Fi-John Chang**

Distinguished Professor

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<http://scholar.google.com/citations?hl=en&user=XZoDI_EAAAAJ>

https://www.researchgate.net/profile/Fi-John\_Chang/stats

**EDUCATION:**

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| Ph.D. (1988) | Civil Engineering, Purdue University, USA |
| B.S.&M.S. | Agriculture Engineering, National Taiwan University, Taiwan |

**PROFESSIONAL EXPERIENCES:**

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| --- | --- | --- |
| 1992~present | **Professor** | Dept. of Bioenvironmental Systems Engineering |
| 2009~present | **Funder** | Taiwan Hydro-Informatics Society, Taiwan |
| 2009~present  2016~present | **Associate Editor**  **Associate Editor** | Journal of Hydrology  Hydrological Sciences Journal |
| 2018~Present | **Editor Board** | Water |
| 2003~2010.7 | **Director** | Agriculture Engineering Research Center (AERC) |
| 1997~2000 | **Chairman** | Dept. of Agriculture Engineering, National Taiwan University, |
| 1994~1997 | **Director** | Hydrotech Research Institute, National Taiwan University, Taiwan |

**RESEARCH INTERESTS:**

Hydrology, Water Resources Management, Artificial Neural Networks, Artificial Intelligence, Ecohydrology, Flood Forecasting, Reservoir Operation, Big-data, Data-mining, Water-Food-Energy Nexus

**HONORS AND AWARDS:**

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| Three times | Outstanding Teaching Awards | National Taiwan University |
| 2005; 2009 | Outstanding Researcher | National Science Council |

**PUBLICATIONS:** Over 190 articles have been published in peer reviewed journals

1. Chang, L.C., Chang, F.J.\*, 2001, “Intelligent control for modeling of real time reservoir operation”, Hydrological Processes, 15(9): 1621-1634. (Highly Sited Paper)
2. Chang, F.J.\*, Chen, Y.C., 2001, “A counterpropagation fuzzy-neural network modeling approach to real-time streamflow prediction”, Journal of Hydrology, 245: 153-164. (Highly Sited Paper)
3. Chang, F. J.\*, Chang, Y.T., 2006, “Adaptive neuro-fuzzy inference system for prediction of water level in reservoir”, Advanced in Water Resources, Vol. 29 pp.1-10, SCI. (Highly Sited Paper)
4. Yanlai Zhou, Fi-John Chang\*, Li-Chiu Chang, I-Feng Kao, Yi-Shin Wang, 2018, “Explore a deep learning multi-output neural network for regional multi-step-ahead air quality forecasts” , Science of the Total Environment (in press)
5. Zhou, Y., Guo, S., Chang, F.J.\*, & Xu, C. Y. (2018). Boosting hydropower output of mega cascade reservoirs using an evolutionary algorithm with successive approximation. Applied Energy, 228,
6. Uen, T. S., Chang, F. J.\*, Zhou, Y., & Tsai, W. P., 2018, “Exploring synergistic benefits of Water-Food-Energy Nexus through multi-objective reservoir optimization schemes”, Science of the Total Environment,633, 341-351.
7. Zhou, Y., Guo, S., Chang, F. J.\*, Liu, P., & Chen, A. B., 2018, “Methodology that improves water utilization and hydropower generation without increasing flood risk in mega cascade reservoirs”, Energy, 143, 785-796.
8. Chen, I. T., Chang, L. C., & Chang, F. J.\*, 2018, “Exploring the spatio-temporal interrelation between groundwater and surface water by using the **self-organizing maps**”, *Journal of Hydrology*, *556*, 131-142.
9. Zhou,Y., Guo, S. Hong, X. Chang, F.J.**\***, 2017, “Systematic impact assessment on inter-basin water transfer projects of the Hanjiang River Basin in China, *Journal of Hydrology*, 553, 584-595
10. Chang, F.J.**\***, Huang, C.W., Cheng, S.T., Chang, L.C., 2017, “[Conservation of groundwater from over-exploitation—Scientific analyses for groundwater resources management](http://www.sciencedirect.com/science/article/pii/S0048969717309877)”, *Science of the Total Environment*, 598, 828-838
11. Bai, T., Kan, Y.B., Chang, J.X., Huang, Q., Chang, F.J.**\***, 2017, “Fusing feasible search space into PSO for multi-objective cascade reservoir optimization”, *Applied Soft Computing*, 51, 328-340
12. Tsai, W.P., Huang, S.P., Cheng, S.T., Shao, K.T., Chang, F.J.**\***, 2017, “A **data-mining framework** for exploring the multi-relation between fish species and water quality through **self-organizing map**”, *Science of the Total Environment*, 579, 474-483
13. Chang, F.J.\*, Chang, L.C., Huang, C.W., Kao, I.F., 2016, “Prediction of monthly regional groundwater levels through hybrid **soft-computing techniques**”, Journal of Hydrology, 541, 965-976
14. Cheng, S.T., Herricks, E., Tsai, W.P., Chang, F.J.\*, 2016, “Assessing the natural and anthropogenic influences on basin-wide fish species richness”, Science of the Total Environment, DOI: 10.1016/j.scitotenv.2016.07.120.
15. Tsai, W.P., Chiang, Y.M., Huang, J.L., Chang, F.J.\*, 2016, “Exploring the Mechanism of Surface and Ground Water through **Data-Driven Techniques** with Sensitivity Analysis for Water Resources Management”, Water Resources Management, 1-18.
16. Chang, F.J.\*, Chen, P.A., Chang, L.C., Tsai, Y.H., 2016, “Estimating spatio-temporal dynamics of stream total phosphate concentration by **soft computing techniques**”, Science of the Total Environment, 562, 228-236.
17. Chang, F.J.\*, Tsai, M.J., 2016, “A nonlinear spatio-temporal lumping of radar rainfall for modelling multi-step-ahead inflow forecasts by **data-driven techniques**”, Journal of Hydrology, 30: 1395-1413.
18. Chang, F.J.\*, Wang, Y.C., Tsai, W.P., 2016, “Modelling Intelligent Water Resources Allocation for Multi-users”, Water Resources Management, 30: 1395-1413.
19. Tsai, W.B., Chang, F.J.\*, Herricks, E.E., 2016, “Exploring the ecological response of fish to flow regime by **soft computing techniques**”, Ecological Engineering, 87: 9-19.
20. Mount, N.J.\*, Maier, H.R., Toth, E., Elshorbagy, A., Solomatine, D., Chang, F.J., Abrahart, R.J., 2016, “**Data-driven modelling** approaches for social-hydrology: Opportunities and challenges within the Panta Rhei Science Plan”, Hydrological Sciences Journal, 61(7), 1192-1208. DOI: 10.1080/02626667.2016.1159683.
21. Tsai, W.B., Chang, F.J.\*, Chang, L.C., Herricks, E.E., 2015, “**AI techniques** for optimizing multi-objective reservoir operation upon human and riverine ecosystem demands”, Journal of Hydrology, 530: 634-644.
22. Chang, F.J.\*, Chiang, Y.M., Ho, Y.H., 2015, “Multi-step-ahead flood forecasts by **neuro-fuzzy networks** with effective rainfall-runoff patterns”, Journal of Flood Risk Management, 8(3): 224-236. DOI: 10.1111/jfr3.12089.
23. Bai, T., Chang, J.X., Chang, F.J.\*, Huang, Q., Wang, Y.M., Chen, G.S., 2015, “Synergistic gains from the multi-objective optimal operation of cascade reservoirs in the Upper Yellow River basin”, Journal of Hydrology, 523: 758–767.
24. Chang, F.J.\*, Tsai, Y.H., Chen, P.A., Coynel, A., Vachaud, G., 2015, “Modeling water quality in an urban river using hydrological factors —**data driven approaches**”, Journal of Environmental Management, 151: 87-96.
25. Chang, L.C., Shen, H.Y., Chang, F.J.\*, 2014, “Regional flood inundation nowcast using hybrid **SOM and dynamic neural networks**”, Journal of Hydrology, 519: 476-489.
26. Chang, F.J.\*, Chung, C.H., Chen, P.A., Liu, C.W., Coynel, A., Vachaud, G., 2014, “Assessment of arsenic concentration in stream water using **neuro fuzzy networks** with factor analysis”, Science of the Total Environment, 494-495: 202-210.
27. Chang, F.J.\*, Chen, P.A., Lu, Y.R., Huang E., Chang, K.Y., 2014, “Real-time multi-step-ahead water level forecasting by **recurrent neural networks** for urban flood control", Journal of Hydrology, 517: 836-846.
28. Chang, F.J.\*, Lai, H.C., 2014, “**Adaptive neuro-fuzzy inference system** for the prediction of monthly shoreline changes in northeastern Taiwan”, Ocean Engineering, 84: 145-156.
29. Tsai, M.J., Abrahart, R.J., Mount, N.J., Chang, F.J.\*, 2014, “Including spatial distribution in a data-driven rainfall-runoff model to improve reservoir inflow forecasting in Taiwan”, Hydrological Processes, 28: 1055–1070.
30. Chang, F.J.\*, Chiang, Y.M., Tsai, M.J, Shieh, M.C., Hsu, K.L., Sorooshian, S., 2014, “Watershed rainfall forecasting using neuro-fuzzy networks with the assimilation of multi-sensor information”, Journal of Hydrology, 508: 374-384.
31. Chang, F. J.\*, Lin, C.H., Chang, K.C., Kao, Y.H., Chang, L.C., 2014, “Investigating the interactive mechanisms between surface water and groundwater over the Jhuoshuei River Basin in Central Taiwan”, Paddy and Water Environment, 12(3): 365-377.
32. Chen, F.W., Liu, C.W.\*, Chang, F.J., 2014, “Improvement of the agricultural effective rainfall for irrigating rice using the optimal clustering model of rainfall station network”, Paddy and Water Environment, 12: 293-406.
33. Chang, F. J.\*, Wang, K.W., 2013, “A systematical water allocation scheme for drought mitigation”, Journal of Hydrology, 507:124-133.
34. Chang, F. J.\*, Chen, P.A., Liu, C.W., Liao, V.H.C., Liao, C.M., 2013, “Regional Estimation of Groundwater Arsenic Concentrations through **Systematical Dynamic-neural Modeling**”, Journal of Hydrology, 499: 265-274.
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36. Chung, C.H., Chang, F. J.\*, 2013, “A refined automated grain sizing method for estimating river-bed grain size distribution of digital images”, Journal of Hydrology, 486: 224-233
37. Chang, F.J.\*, Sun, W., Chung, C.H., 2013, “Dynamic factor analysis and artificial neural network for estimating pan evaporations at multiple stations in northern Taiwan”, Hydrological Sciences Journal, 58(4): 813-825, DOI:10.1080/02626667.2013.775447.
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39. Chang, F.J.\*, Tsai, W.B., Chen, H.K., Yam, R.S.W., Herricks\*, E.E., 2013, “A **Self-Organizing Radial Basis Network** for estimating riverine fish diversity”, Journal of Hydrology, 476: 280-289
40. Chang, L.C., Chen, P.A., Chang, F.J.\*, 2012, “Reinforced Two-Step-Ahead Weight Adjustment Technique for On-Line Training of Recurrent Neural Networks”, **IEEE Transactions on Neural Networks and Learning Systems**, 23(8): 1269-1278
41. Chiang, Y.M., Cheng, W.G., Chang, F.J.\*, 2012, “A hybrid artificial neural network-based agri-economic model for predicting typhoon-induced losses”, Natural Hazards, 63(2): 769-787
42. Chang, F.J.\*, Chung, C.H., 2012, “Estimation of riverbed grain-size distribution using image-processing techniques”, Journal of Hydrology, 440-441: 102-112
43. Chung, C.H., Chiang, Y.M., Chang, F.J.\*, 2012, “A spatial neural fuzzy network for estimating pan evaporation at ungauged sites”, Hydrology and Earth System Sciences, 16: 255-266.
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45. Wang, K.W., Chang, L.C., Chang, F.J.\*, 2011, “Multi-tier interactive genetic algorithms for the optimization of long-term reservoir operation”, Advances in Water Resources, 34(10): 1343-1351.
46. Chiang, Y.M., Chang, L.C., Tsai, M.J., Wang, Y.F., Chang, F.J.\*, 2011, “Auto-control of pumping operations in sewerage systems by rule-based fuzzy neural networks”, Hydrology and Earth System Sciences, 15: 185-196. Chang, L.C., Chang, F.J.\*, Hsu, H.C., 2010, “Real-Time Reservoir Operation for Flood Control Using Artificial Intelligent Techniques”, International Journal of Nonlinear Sciences and Numerical Simulation, 11(11): 887-902.
47. Chiang, Y.M., Chang, L.C., Tsai, M.J., Wang, Y.F., Chang, F.J.\*, 2010. “Dynamic Neural Networks for Real-Time Water Level Predictions of Sewerage Systems-covering gauged and unguaged sites”, Hydrology and Earth System Sciences, 14: 1309-1319.
48. Chang, L.C.,Chang, F.J.\*, Wang, K.W., Dai, S.Y., 2010, “Constrained Genetic Algorithms for Optimizing Multi-use Reservoir Operation”, Journal of Hydrology, 390: 66-74.
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51. Chang, F.J.\*, Chang, L.C., Kao, H.S., Wu, G.R., 2010. “Assessing the effort of meteorological variables for evaporation estimation by Self-Organizing Map Neural Network”, Journal of Hydrology, 384: 118-129.
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61. [Liao, C.M](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Liao%20CM&ut=000261082600007&pos=1).\*, [Jau, S.F](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Jau%20SF&ut=000261082600007&pos=2)., [Chen, W.Y](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Chen%20WY&ut=000261082600007&pos=3)., [Lin, C.M](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Lin%20CM&ut=000261082600007&pos=4)., [Jou, L.J](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Jou%20LJ&ut=000261082600007&pos=5)., [Liu, C.W](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Liu%20CW&ut=000261082600007&pos=6)., [Liao, V.H.C](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Liao%20VHC&ut=000261082600007&pos=7)., [Chang, F.J](http://apps.isiknowledge.com/OneClickSearch.do?product=UA&search_mode=OneClickSearch&db_id=&SID=Q2pC8Cp4JffapJDhCFh&field=AU&value=Chang%20FJ&ut=000261082600007&pos=8)., 2009,“Acute Toxicity and Bioaccumulation of Arsenic in Freshwater Clam Corbicula fluminea”, Environmental Toxicology, 23(6): 702-711.
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64. Chang, F.J.\*, Tsai, M.J., Tsai, W.P., Herricks, E.E., 2008, “Assessing the Ecological Hydrology of Natural Flow Conditions in Taiwan”, Journal of Hydrology, 354:.75-89.
65. Chaves, P., Chang, F.J.\*, 2008, “Intelligent Reservoir Operation System Based on Evolving Artificial Neural Networks”, Advances in Water Resources, 31: 926-936.