"111 Centre on Biological Computing and Artificial Intelligence" , Dalian University (DLU)

Cognitive System Engineering

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Research Course DLU 2024

Cognitive System Engineering

Cognitive systems (CogSys) are software-hardware systems that have their structure and functionality based on principles of information processing in the human brain. They are part of AI, but AI includes also other systems that manifest cognitive behaviour, such as speech and image recognition, learning and reasoning, but using other methods , such as statistical, empirical, abstract logic , etc.

The course is by research papers.
Every topic will include:

1. Topic/task/problem specification
2. Previously published methods for solving the problem
3. Description of the method and in the paper under discussion
4. Experimental results and discoveries
5. Future work to be done for this problem
6. Questions for individual work for those interested

Additional materials: https://www.knowledgeengineering.ai/china

ZOOM link for all lectures: https://us05web.zoom.us/j/4658730662?pwd=eFN0eHRCN3o4K0FaZ0lqQmN1UUgydz

CogSysEn: Lecture Topics

1. Introduction to the course

Part I : Learning systems

2. Deep learning and deep knowledge representation in the human brain

-Chapter 3 from: N.Kasabov, Time-space, spiking neural networks and brain-inspired artificial intelligence, Springe-Nature, 2029

3.Modelling brain dynamics

- Benuskova, L., Kasabov, N. Modeling brain dynamics using computational neurogenetic approach. Cogn Neurodyn 2, 319–334 (2008). https://doi.org/10.1007/s11571-008-9061-1

4. Evolving learning systems

- N. Kasabov, "Evolving fuzzy neural networks for supervised/unsupervised online knowledge-based learning," in IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), vol. 31, no. 6, pp. 902-918, Dec. 2001, doi: 10.1109/3477.969494.

5. Neuro—fuzzy learning and inference systems: DENFIS

- Kasabov, N. K., & Song, Q. (2002). DENFIS: dynamic evolving neural-fuzzy inference system and its application for time-series prediction. IEEE transactions on Fuzzy Systems, 10(2), 144-154.

6. Spatio-temporal learning systems: SNN

- N. Kasabov, K. Dhoble, N. Nuntalid, G. Indiveri, Dynamic evolving spiking neural networks for on-line spatio- and spectro-temporal pattern recognition. Neural Networks, 41(1995), 188–201 (2013). https://doi.org/10.1016/j.neunet.2012.11.014.

7. Reservoir computing and Brain-inspired SNN

- S. Schliebs, A. Mohemmed, N. Kasabov, Are probabilistic spiking neural networks suitable for reservoir computing? in International Joint Conference on Neural Networks (San Jose, USA, 2011), pp. 3156–3163.

- N. Kasabov, NeuCube: a spiking neural network architecture for mapping, learning and understanding of spatio-temporal brain data. Neural Netw. 52(2014), 62–76 (2014).

8. Integrated learning systems:

- *P. Koprinkova-Hristova, D. Penkov, S. Nedelcheva, S. Yordanov and N. Kasabov, "On-line Learning, Classification and Interpretation of Brain Signals using 3D SNN and ESN," 2023 International Joint Conference on Neural Networks (IJCNN), Gold Coast, Australia, 2023, pp. 1-6, doi: https://doi.org/10.1109/IJCNN54540.2023.10191974,*
- AbouHassan et al, *NeuDen: Integrating evolving Neuromorphic spiking neural networks and Dynamic evolving neuro-fuzzy systems for predictive and explainable learning of multiple time series*

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CogSysEn: Lecture Topics

Part II. Associative memories

9. Spatio-Temporal Associative Memories in SNN

- *Kasabov, Nikola (2023). STAM-SNN: Spatio-Temporal Associative Memories in Brain-inspired Spiking Neural Networks: Concepts and Perspectives. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.23723208.v1*

10. Associative memories for neuroimaging data: EEG and fMRI

- *N K. Kasabov, H Bahrami, M Doborjeh, A Wang, Brain Inspired Spatio-Temporal Associative Memories for Neuroimaging Data: EEG and fMRI, Bioengineering 2023, MDPI 10(12), 1341 https://doi.org/10.3390/bioengineering10121341, www.mdpi.com/journal/bioengineering*

11. Audio-visual associative memories

- *N Kasabov, B Sen Bhattacharya, D Patel, N Aggarwal, T Bankar, IAbouHassan, Cognitive Audio-Visual Associative Memories using Brain-inspired Spiking Neural Networks with Case Studies on Moving Object Recognition (subm. IEEE Trans. Cognitive and Developm. Systems, 2023).*

12. Predictive associative memories for time series

- *AbouHassan, I; Kasabov, N; Bankar, T; Garg, R; Sen Bhattacharya, B (2023). PAMeT-SNN: Predictive Associative Memory for Multiple Time Series based on Spiking Neural Networks with Case Studies in Economics and Finance. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.24063975.v1, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4665533*

Part III. Software and Hardware Implementation of CogSys.

13. Software implementation of CogSys in Python

- *NeuCubePy*

14. Neuromorphic implementation of CogSys. China neuromorphic hardware systems for CogSys.

- *J. Behrenbeck, Z. Tayeb, C. Bhiri, C. Richter, O. Rhodes, N. Kasabov, S. Furber, J. Conrad, Classification and Regression of Spatio-Temporal EMG Signals using NeuCube Spiking Neural Network and its implementation on SpiNNaker Neuromorphic Hardware. J. Neural Eng. (IOP Press, Article reference: JNE-102499) (2018). http://iopscience.iop.org/journal/1741-2552.*

  - *paper for CogSys on Loihi chip and on China neuromorphic chips*

15. Quantum computation

- *Ravi , N. Kasabov et al, (2023). From Quantum Computing to Quantum-inspired Computation for Neuromorphic Advancement – A Survey. TechRxiv. Preprint. https://doi.org/10.36227/techrxiv.24053250.v1*

16. Revision of the course

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