Title: **Spiking Neural Networks and Deep Learning of Temporal and Spatio-Temporal Data (3 hours)**

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Abstract:

The current development of the third generation of artificial neural networks - the spiking neural networks (SNN) along with the technological development of highly parallel hardware systems, makes it possible to learn complex temporal or spatio-temporal data in a more efficient, brain-like way and to predict future events [1,2].

The tutorial presents first fundamental principles of learning in SNN, including: spike data encoding; unsupervised and supervised learning in SNN; SNN for classification and regression. Then the talk introduces some brain-like SNN architectures and the principles of deep learning in them illustrated with an implementation, dubbed NeuCube [3,4]. Deep learning in a SNN does not require a fixed multilayer structure to be defined in advance and many iterations of training in this structure as it is the case with the current deep neural networks. The talk introduces also a methodology for the design and implementation of SNN application systems for deep learning, pattern recognition and predictive data modelling on temporal or spatio-/spectro temporal data [5,11]. As an example, a SNN development system has been created for the development and testing of SNN application systems for temporal or spatio/spectro temporal data across domain areas [5,11] (http://[www.kedri.aut.ac.nz/neucube/](http://www.kedri.aut.ac.nz/neucube/)).

The deep learning approach with SNN is illustrated on benchmark problems and data with different characteristics and applications: brain data modelling in neuroinformatics; personalised modelling and event prediction in bioinformatics and neuroinformatics; brain-computer interfaces; multisensory data analysis and pattern recognition in a real time, such as air pollution sensors and seismic sensors, predictive modelling of financial time series, deep learning of audio-visual data, fast moving object recognition, and others. The talk discusses parallel implementations of SNN systems on various computational platforms, including: PCs; GPUs; tensor flow machines; highly parallel neuromorphic hardware platforms [7, 8]. Such SNN applications are not only significantly more accurate and faster than traditional machine learning systems, including the current deep neural networks, but they lead to a significantly better understanding of the data and the processes that generated it and to a flexible, adaptive learning for on-line applications. New directions for the development of SNN systems are pointed towards a further integration of principles from the science areas of computational intelligence, bioinformatics and neuroinformatics and new applications across domain areas [9,10].

Related Publications:

1. EU Marie Curie EvoSpike Project (Kasabov, Indiveri): <http://ncs.ethz.ch/projects/EvoSpike/>
2. Schliebs, S., Kasabov, N. (2013). Evolving spiking neural network-a survey. Evolving Systems, 4(2), 87-98.
3. Kasabov, N. (2014) NeuCube: A Spiking Neural Network Architecture for Mapping, Learning and Understanding of Spatio-Temporal Brain Data, *Neural Networks,* 52, 62-76.
4. Kasabov, N., Dhoble, K., Nuntalid, N., Indiveri, G. (2013). Dynamic evolving spiking neural networks for on-line spatio- and spectro-temporal pattern recognition. Neural Networks, 41, 188-201.
5. Kasabov, N. et al (2016) A SNN methodology for the design of evolving spatio-temporal data machines, Neural Networks, 2016.
6. Kasabov, N., et al. (2014). Evolving Spiking Neural Networks for Personalised Modelling of Spatio-Temporal Data and Early Prediction of Events: A Case Study on Stroke. Neurocomputing, 2014.
7. Furber, S. et al (2012) Overview of the SpiNNaker system architecture, IEEE Trans. Computers, 99.
8. Indiveri, G., Horiuchi, T.K. (2011) [Frontiers in neuromorphic engineering](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3189639/), *Frontiers in* *Neuroscience*, 5, 2011.
9. Kasabov, N. (ed) (2014) The Springer Handbook of Bio- and Neuroinformatics, Springer.
10. Kasabov, N (2017) Spiking Neural Networks and Deep Learning of Temporal and Spatio-Temporal Data, Springer.

Bio: **Professor Nikola Kasabov is** Fellow of IEEE, Fellow of the Royal Society of New Zealand, DVF of the Royal Academy of Engineering and the Scottish Infortmatics and Computing Association. He is the Director of the Knowledge Engineering and Discovery Research Institute (KEDRI), Auckland and Professor at the School of Engineering, Computing and Mathematical Sciences at Auckland University of Technology. Kasabov is a Past President and Governor Board member of the International Neural Network Society (INNS) and also of the Asia Pacific Neural Network Society (APNNS). He is a member of several technical committees of IEEE Computational Intelligence Society and a Distinguished Lecturer of the IEEE CIS (2012-2014). He is a Co-Editor-in-Chief of the Springer journal Evolving Systems and serves as Associate Editor of Neural Networks, IEEE TrNN, IEEE Tr CDS, Information Science, Applied Soft Computing and other journals. Kasabov holds MSc and PhD from the TU Sofia, Bulgaria. His main research interests are in the areas of neural networks, intelligent information systems, soft computing, bioinformatics, neuroinformatics. He has published more than 600 publications that include 12 books, 180 journal papers, 80 book chapters, 28 patents and numerous conference papers. His work has been sited more than 12,000 times, with an H-factor of 48. He has extensive academic experience at various academic and research organizations in Europe and Asia, including: TU Sofia, University of Essex UK, University of Otago, Advisor Professor at the Shanghai Jiao Tong University, Visiting Professor at ETH/University of Zurich and the RGU, UK. Prof. Kasabov has received a number of awards, among them: the APNNA ‘Outstanding Achievements Award’; the INNS Gabor Award for ‘Outstanding contributions to engineering applications of neural networks’; the EU Marie Curie Fellowship; the Bayer Science Innovation Award; the APNNA Excellent Service Award; the RSNZ Science and Technology Medal, and others. He has supervised to completion 48 PhD students. More information of Prof. Kasabov can be found on the KEDRI web site: <http://www.kedri.aut.ac.nz>