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Brain-Inspired Spiking Neural Network Architectures for Deep, Incremental Learning and Knowledge Evolution

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ABSTRACT.

The talk demonstrates that the third generation of artificial neural networks, the spiking neural networks (SNN) are not only capable of deep, incremental learning of temporal or spatio-temporal data, but also enabling the extraction of knowledge representation from the learned data and tracing the knowledge evolution over time from the incoming data. Similarly to how the brain learns, these SNN models do not need to be restricted in number of layers, neurons in each layer, etc. as they adopt self-organising learning principles of the brain. The talk covers:

1. Algorithms for deep, incremental and potentially “life-long” learning in SNN.
2. Algorithms for knowledge representation and for tracing the knowledge evolution in SNN over time from incoming data.
3. Selected Applications

The material is illustrated on an exemplar SNN architecture NeuCube (free software and open source along with a cloud-based version available from www.kedri.aut.ac.nz/neucube). Case studies are presented of brain and environmental data modelling and knowledge representation using incremental and transfer learning algorithms. These include: predictive modelling of EEG and fMRI data measuring cognitive processes and response to treatment; AD prediction; understanding depression; predicting environmental hazards and extreme events.

It is also demonstrated that brain-inspired SNN architectures, such as the NeuCube, allow for knowledge transfer between humans and machines through building brain-inspired Brain-Computer Interfaces (BI-BCI). These are used to understand human-to-human knowledge transfer through hyper-scanning and also to create brain-like neuro-rehabilitation robots. This opens the way to build a new type of AI systems – the open and transparent AI.

Reference: N.Kasabov, *Time-Space, Spiking Neural Networks and Brain-Inspired Artificial Intelligence*, Springer, 2019, <https://www.springer.com/gp/book/9783662577134>.

Biodata:



Professor Nikola Kasabov is Fellow of IEEE, Fellow of the Royal Society of New Zealand, Fellow of the INNS College of Fellows, DVF of the Royal Academy of Engineering UK. He is the Founding 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, New Zealand. Kasabov is the 2019 President of the Asia Pacific Neural Network Society (APNNS) and Past President of the International Neural Network Society (INNS). He is member of several technical committees of IEEE Computational Intelligence Society and Distinguished Lecturer of IEEE (2012-2014). He is Editor of Springer Handbook of Bio-Neuroinformatics, Springer Series of Bio-and Neuro-systems and Springer journal Evolving Systems. He is Associate Editor of several journals, including Neural Networks, IEEE TrNN, Tr CDS, Information Sciences, Applied Soft Computing. Kasabov holds MSc and PhD from 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 620 publications. He has extensive academic experience at various academic and research organisations in Europe and Asia, including: TU Sofia Bulgaria; University of Essex UK; University of Otago, NZ; Advisory Professor at Shanghai Jiao Tong University and CASIA China, Visiting Professor at ETH/University of Zurich and Robert Gordon University UK, Honorary Professor of Teesside University, UK. Prof. Kasabov has received a number of awards, among them: *Doctor Honoris Causa* from Obuda University, Budapest; INNS Ada Lovelace Meritorious Service Award; NN Best Paper Award for 2016; APNNA 'Outstanding Achievements Award'; INNS Gabor Award for 'Outstanding contributions to engineering applications of neural networks'; EU Marie Curie Fellowship; Bayer Science Innovation Award; APNNA Excellent Service Award; RSNZ Science and Technology Medal; 2015 AUT Medal; Honorable Member of the Bulgarian, the Greek and the Scottish Societies for Computer Science. More information of Prof. Kasabov can be found from: <http://www.kedri.aut.ac.nz/staff>.