Spiking Neural Networks for Machine Learning and Predictive Data Modelling: Methods, Systems, Applications

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This tutorial introduces spiking neural networks (SNN), their methods, implementations and applications. SNNs use principles of information processing, also characteristic of the brain. Information is represented in the form of many sequences of spatio-temporal potentials (spikes) that are transferred between many neurons through connections. When applied for data modelling SNNs have the potential of compact representation of space and time, fast information processing, time-based and frequency-based information representation, efficient learning and generalisation on complex data, predictive spiking activity that can trigger in advance a necessary response [1-6]. SNNs can revolutionise computing in general and that is why SNN have been chosen as the main information processing paradigm for the development of new computing, neuromorphic systems in the EU Human Brain Project, the USA Brain project, and others. The tutorial will include materials and demonstrations organized in three parts:

*Part 1. Introduction to SNN***:** Methods of data encoding and learning in SNN [1-6].

*Part 2. SNN model design and system implementation***:** All steps of the design of a machine learning model for complex temporal or spatio-/spectro temporal data modelling are discussed, including: a) Input data transformation into spike sequences; (b) Learning spatio-temporal spike sequences in a scalable 3D SNN reservoir; (c) On-going learning and classification of data over time; (d) Dynamic parameter optimization [7]; (e) Predictive data modelling with the SNN, so that once a SNN is trained on whole input patterns related to a given outcome (occurrence of an event), the SNN predicts this event earlier in time and accurately when new, partial data is entered [8]; (f) Adaptation of the SNN model on new data, possibly in an on-line/ real time mode [2]; (g) SNN model visualisation and interpretation for a better understanding of the data and the processes that generated it. Implementations of the SNN models as both software [9] and neuromorphic hardware systems [10] are discussed and demonstrated, including the use of SpiNNaker [11].

Part 3. SNN applications for temporal-, or spatio-/spectro-temporal data modeling and pattern recognition: Applications across domain areas are demonstrated, including: moving object recognition [5]; predictive modelling systems [8]; brain data modeling [12,13]; neurogenetic systems [14,15]. Challenging open problems and future directions are presented [16].

References (the papers by the presenters are available from www.kedri.aut.ac.nz)

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