Abstract

This thesis has explored the possibilities of applying brain-inspired algorithms like Spiking Neural Network (SNN) for developing useful low power applications. SNN has advantages in terms of reduced computational complexity due to its event-driven processing nature. Applications in the field of biomedical devices and the Internet of Things (IoT) are studied. Neuromorphic architectures can be developed using a digital, analog, or mixed approach. The mixed-mode style is preferred as it leverages the advantages of both digital and analog modes. Different learning algorithms for SNN exist in literature. Two such algorithms, namely modified Hebbian Spike-timing-dependent plasticity (STDP) and backpropagation for conversion networks have been utilized on the target application. SNN inference architectures using digital and analog resistive crossbar networks (RCNs) have been analyzed and compared in terms of energy efficiency and performance. A low power spike sorting system applicable to implantable brain devices has been proposed. Here, one suggests a 2-step shared training module which will have benefits in terms of developing energy-efficient signal acquisition channels. This method is beneficial for multi-channel implantable brain-machine-interface (BMI) systems as the future trend is geared toward an increasing number of electrodes. The feasibility of SNN has been explored for the classification of surface myoelectric signals for Human-Computer Interaction (HCI) systems. Here one compares its performance and computational complexity with an artificial neural network (ANN) model. The present research has continued toward developing intelligent Internet of things (IoT) devices applicable to security surveillance applications. The main focus has been laid on efficient and approximate in-sensor computation of the wireless sensor nodes (WSN). Two types of sensors have been considered, viz., 1) acoustic, and 2) image. The acoustic sensor is used for detecting human footsteps in the presence of background noise. The image sensors are intended for classifying humans versus animals for different scenarios such as farm and forest. In both cases, extensive analysis has been performed to assess the feasibility and performance of SNN algorithms. Also, energy-efficient feature extraction methods have been adopted so as to ensure that the overall system consumes low power. For all the problems mentioned above, algorithmic level optimization has been undertaken, followed by architectural level implementation of the overall system.

Keywords: neuromorphic computing, spiking neural network (SNN), resistive crossbar network (RCN), low power application, biomedical devices, brain-machine-interface (BMI), human-computer interaction (HCI), Internet of things (IoT) surveillance, wireless sensor node (WSN).