ABSTRACT

This thesis proposes a novel technique for implementing a rateless coding scheme by employing intelligent methods, where the agent learns to decide the corresponding rate given a channel capacity. The main concepts behind reinforcement learning (RL)-based rateless coding are (i) learning capability of the decoder and (ii) learning capability of rate determination to satisfy the Shannon channel coding theorem. This thesis integrates both a transfer learning (TL) framework and a reinforcement learning framework to address this concept.

This thesis: (i) studies machine learning (ML) structure for box-plus operation as an element of future error correction based on artificial intelligence (AI) using soft information processing with log-likelihood ratio (LLR) values, (ii) investigates the best structure of neurons in ML to deal with box-plus operation, (iii) utilizes a TL approach to learn a generalized message-passing algorithm for quasi-cyclic low-density parity-check (QC-LDPC) codes, by replacing the node and edge message updates with trainable weights, and (iv) proposes RL using a Q-learning algorithm.

This thesis found that a single hidden layer with many neurons is better than multiple hidden layers with less number of neurons, because the box-plus operation is simple. This thesis found that the proposed TL scheme for traditional QC-LDPC decoding in terms of sign error rate achieves outstanding performance although additional extended parity (EP) is required. The proposed RL approach using the Q-learning algorithm significantly outperforms the Sarsa algorithm in terms of cumulative reward and accuracy. This result indicates that the agent successfully learned the best policy to choose the appropriate code rate for the given current channel capacity. Finally, this thesis also evaluates the proposed intelligent methods in terms of bit-error-rate (BER) and frame-error-rate (FER) performance. The RL-based rateless coding scheme in terms of FER obtains a 3.5 dB gain compared to the fixed rate LDPC codes. The results confirm that the intelligent design can learn the rateless decoding scheme and can achieve a decoding performance similar to that of traditional decoding of QC-LDPC codes. The result of this thesis is expected to open possibilities for the development of future error correction codes based on AI.

Keywords: Artificial intelligence, transfer learning, RL, rateless coding.