Neural Networks as Fitness Evaluators in Genetic Algorithms: Simulating Human Creativity

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Introduction

While complex symbolic models of creative processes like music or poetry generation produce remarkable results (Cope, 1996), it may prove advantageous to model creativity more explicitly in terms of adaptive processes of "blind variation and selective retention" (Campbell, 1960)). One computational approach that seems to be particularly promising in this regard is genetic programming (Mitchell, 1996). However, when applying this approach to a complex domain like the creation of works of art, one fundamental problem that arises is the specification of a fitness operator for the selection of the surviving individuals. How can one specify what a good poem or musical piece or painting is? The current model tries to solve this problem by exploring the use of a neural network (NN), which was trained on human evaluations, as fitness evaluator for a genetic algorithm (GA).

Architecture of the Model

The specific domain chosen was limerick generation because of the shortness and clearly defined structure (AABBA) of this poetic form. A lexicon of 1,107 “limerable” words was created using the words of 50 naturally and artificially created limericks. The syllables of each word were represented as binary vectors coding the phonemes and the stress pattern. Information about word class and meaning were left out for the sake of parsimony and computational feasibility. The initial population of limericks was generated by selecting the rhyming words, and then filling each line in accord with the stress template.

Unlike Burton and Vladimirova (1997), who have interfaced an ART NN with a GA for music generation, we were interested in a fitness evaluator that simulates human judgments about limericks. To this end, we obtained quality ratings on a scale from 1 – 6 for 25 naturally and 25 artificially created limericks from 160 participants. A simple recurrent NN was then trained on 36 limericks to associate the median ratings. When tested on the remaining 14 limericks, it produced reliably higher values for natural (3.4) than for artificial limericks (1.9), $t(12) = 2.1$, $p = .05$, as did the human participants (natural: 4.8, artificial: 1.7, $t(12) = 5.4$, $p < .01$). This indicates that the NN clearly captured some important dimensions used by humans to evaluate the quality of limericks. The NN was then interfaced with the GA so as to provide the fitness measure, which was used as the basis for the selection of the fittest individuals from each generation. The selected limericks were then modified using mutation, crossover, and direct-copy operators to create the next generation of limericks.

Simulation Results

The model was run for 1000 generations. In order to determine whether there was improvement in limerick quality, we compared the fitness measures assigned by the NN to the first (1.2) and last 100 (1.6) generations, and observed a small but significant improvement, $t(198) = 9.3$, $p < .001$. This first result encourages us to suggest that training NNs to simulate human judgment in complex domains, and using them as fitness evaluators in GAs, may prove fruitful for the generation of products that typically are dependent on human insight and creativity.

References

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