A Strategy for Handling Type-2 Problems

István S. N. Berkeley
Philosophy Department, USL P. O. Drawer 43770
The University of Southwestern Louisiana
Lafayette, LA 70405-3770
istvan@usl.edu

In a recent widely circulated paper, Clark and Thornton (in press) identify a class of learning problem they call 'Type-2' problems (the paper is currently available from ftp.princeton.edu/pub/harnad/BBS/.WWW/bbs.clark.html). Type-2 problems are those in which a regularity in a data set can only be found by testing or measuring relational properties in the data set, which can only be discovered by employing a recoding function. According to Clark and Thornton (p. 5), there are an infinite number of possible recoding functions for any Type-2 problem. As a consequence of this, the probability of an uninformed learning mechanism hitting upon a recoding function, which will not only solve the problem, but will also permit successful generalization, is close to zero.

Clark and Thornton (in press) claim that additional constraints must be applied to uninformed learning mechanisms in order for such mechanisms to exhibit generalization on type-2 problems. The class of type-2 problems are both important and significant as, according to Clark and Thornton, problems of this type are "...rife in biologically realistic settings and in domains ranging from simple animat (simulated animal or autonomous robot) behaviors to language acquisition."

Despite the apparently problematic nature of such problems though, it appears that problems of this kind are regularly solved by biological systems. The puzzle is to figure out a way of solving these problems using automated learning procedures. Ideally, approaches to solving type-2 problems should be such that they avoid "...a very heavy-duty nativism and an amazing diversity of task specific, on-board learning devices..." (Clark & Thornton, p. 11). Rather, a strategy must aim at reducing the search space for type-2 problems, without being excessively task specific, nativist or *ad hoc*. This then is the challenge of type-2 problems for automated learning procedures.

Although Clark and Thornton explore a number of means by which type-2 problems can be solved (e.g. incremental learning, modular networks and representational redescription), they do not consider the effect of employing processing units with non-monotonic activation functions.

Dawson and Schopflocher (1992) described a kind of processing unit, which they call 'value units', that have a non-monotonic Gaussian activation function. Berkeley et al. (1995) have shown that these units can be sensitive to relational properties. As Clark and Thornton supported their claims about type-2 problems by running numerous simulations, a similar stratergy can be employed to assess the performance of value units on type-2 problems.

Clark and Thornton studied the 4-bit parity problem in their investigation of type-2 problems. None of their systems exhibited any generalization. A series of simulations employing a number of networks of value units, trained upon the same problem, were run in order to gain a preliminary assessment of the performance of value units on type-2 problems. All networks had four input units, a single hidden unit and a single output unit. 16 training sets were developed, each consisting of 15 training patterns. The remaining untrained pattern from each data set was then used to assess the generality of the solutions discovered by the networks upon convergence. This test of generalization was the same as that used by Clark and Thornton in their simulation studies.

Each training set was trained 11 times, giving a total of 176 simulations. The convergence criterion for each of these simulations was set at 0.025 and in each case a learning rate of 0.01 and a momentum of 0.0 were used. A total of 97 (55%) of these networks reached convergence, with a mean sum squared error of 0.008 for the training sets.

Of the value unit networks which reached convergence, 63% succeeded in generalizing correctly when presented with the untrained pattern. The mean error for the unseen patterns for these networks was 0.017 This stands in sharp contrast to the results reported by Clark and Thornton. They did not observe a single instance in which a network was able to correctly generalize on the single withheld pattern.

These results indicate that Clark and Thornton's claims about type-2 problems are not straightforwardly applicable to the class of *all* automated learning procedures. Rather, under certain circumstances a useful strategy for handling the difficulties presented by type-2 problems may be to use non-monotonic processing units.

References

Berkeley, I., Dawson, M., Medler, D., Schopflocher, D., & Hornsby, L. (1995). Density plots of hidden unit activations reveal interpretable bands. *Connection Science*, *7*, 167-186.

Clark, A., & Thronton, C. (in press). Trading spaces: Computation, representation, and the limits of uninformed learning. *Behavioral and Brain Sciences*.

Dawson, M., & Schopflocher, D. (1992). Modifying the generalized delta rule to train networks of non-monotonic processors for pattern classification. *Connection Science*, *4*, 19-31.