Advice on Reasoning from First Principles in a Psychodiagnostic Domain

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Currently, two approaches to the problem of diagnosis prevail. The probabilistic approach is to collect diagnostic behavior, link it to the possible malfunctions, and add a calculus for a confidence measure. The other approach, model-based diagnosis, is to start from a model of the diagnostic domain, and use a deductive system to infer hypotheses about malfunctions. Both approaches generally require a sequence of observations to obtain an unequivocal diagnosis.

Our research can be characterized by a quote from Davis and Hamscher (1988, p. 335): "... an intriguing experiment would be to go out on the edge and apply this technique in a domain where it is not at all obvious that it will work". As a starting point for such an exploration we chose a non-technical domain, namely psychodiagnostics. Since we had the expertise readily available in our institute, we focused on the problems young children encounter when they start learning how to read. The domain is challenging for three reasons:

- Model-based diagnosis assumes that an underlying model is available. This is obviously the case for man made devices, but for our domain such a model was not available. New and interesting problems may emerge when a model has to be constructed to fit the model-based approach.
- Many practitioners are dissatisfied with the results of their methods, and they often lack consensus. Since the probabilistic approach has dominated the field of psychodiagnostics, the apparent success of model-based diagnosis holds a promise that must be pursued.
- If the poor results are not due to the method but to deficient knowledge, attempting the entirely different and principled approach of model-based diagnosis may shed new light on the structure of the domain.

Model-based diagnosis has three aspects to consider for a new domain (De Kleer & Williams, 1987). (a) It requires a model. In our case an appropriate model was not available, so we needed to build one. Let us call this the modeling phase. (b) Once a model has been built, we need to derive diagnostic hypotheses. We call this the hypotheses generation phase. (c) Since more than one set of hypotheses may explain the observed discrepancies, subsequent observations may be called for to discriminate between the alternatives. This we call the testing phase.

In our study of 55 children between 9 and 13 years old, we encountered problems in all three phases of applying model-based diagnosis to a psychodiagnostic domain (Grimbergen, 1994):

- *Modeling phase:* Model-based diagnosis requires of a model that (a) it consists of joined components, (b) for each which the input/output mapping is known, (c) its behavior, both normal and defective, should correspond to the behavior in the domain to be modeled. Our psychodiagnostic domain violated all three requirements.
- *Hypothesis generation phase:* A fixed set of components did not fit well with the child's reading behavior. Instead we had to assume that a subset is taken from a set of available components. This introduces two kinds of errors. First, a chosen component may work incorrectly (as in the 'fault models' framework). Second, we discovered that a correct component may be chosen at the wrong time. We called this *assembly errors*, as if soldering a correct component in the wrong place on a circuit board.
- *Testing phase:* Textbook examples assume that the model is always available and complete, and that assembly errors do not occur. The third assumption is that devices permit unrestricted measurement over components. However, in the psychodiagnostic domain it is difficult to penetrate the actual model, so that testing individual components is hardly possible. We call this the *closed box* situation, one which pervades the psychodiagnostic domains known to us.

We found that certain new problems (assembly errors and closed box) could be handled by exploiting domain restrictions that made the solutions tractable. However, there is no guarantee that other domains allow similar solutions to the model-based approach. Additional research in the field of model-based diagnosis should therefore focus more attention on the circumstances under which the paradigm is applicable.

References

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