Being Right for the Right Reason: Better Than Just Being Right?

The management of knowledge and experience is critical for diagnostic quality in nuclear medicine. Research in computer sciences, cognitive sciences, and artificial intelligence has created conceptual frameworks, techniques, and tools that can be applied to construct computer programs that perform tasks such as diagnosis, explanation, and planning. Different approaches to knowledge engineering that are currently available permit a formal codification of knowledge and inference guidelines for automated computer-based problem solving.

Expert systems represent a specific framework for knowledge processing systems that is particularly suitable for problem solving when the knowledge domain is narrow and when knowledge can be encoded in the form of "if…then…else" rules (*1*). Expert systems reason with domain-specific knowledge that can be symbolic as well as numeric. Expert systems can use domain-specific methods that are heuristic as well as algorithmic. Domain experts and knowledge engineers work together to develop the knowledge base as a set of rules that apply to and completely describe a particular problem space. When the rule-based system is challenged with a new problem, an inference engine searches for and generates a chain of rules that link the specification of a problem to its solution. In nuclear medicine, an unknown case may be specified by quantitative or qualitative parameters of time–activity curves or by regional tracer distributions. During the inference process, uncertainty in the rule base as well as the data can be incorporated. When a final conclusion is reached, the chain of rules can be traced back from the solution to the problem. The rule chain can then be presented to the user in the form of sentences as an explanation of the diagnostic process. Rule-based expert systems therefore can describe how a solution was obtained. Such an explanation is useful during system development, as it permits debugging of the rule base. In addition, an explanation offers to the user confidence in the system as the logical chain is made transparent. Rule-based systems therefore have the potential to educate about the problem domain as they guide the user toward a solution.

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On pages 463–470 of this issue of *The Journal of Nuclear Medicine*, Garcia et al. (*2*) evaluate the inference engine of an expert system that generates explanations of the reasoning process for diagnosing renal obstruction from diuresis renography. The authors previously presented a rule-based expert system for confirming or excluding renal obstruction from diuresis nephrograms with a high diagnostic accuracy (*3*). As indicated in their present study (*2*), fewer than 3 diuresis nephrography studies are performed per week in an average nuclear medicine department. Therefore, it is difficult to acquire or maintain expertise for this imaging protocol. Thus, an expert system for interpreting diuresis nephrography studies has the potential to improve the diagnostic process and provide education to users with more limited experience. Therefore, diuresis nephrography was appropriately chosen by the authors as the problem domain for their expert system.

In the present study, Garcia et al. (*2*) extend their previous work by evaluating the justification engine that documents the reasoning process of the expert system in English sentences. An expert system could provide the right answers for the wrong reasons. Initially, it would appear to be irrelevant whether the reasoning process is indeed correct or is incorrect if the final answer is correct. However, a more detailed analysis of and research on expert systems reveal that the clinical acceptability of an expert system strongly depends on user acceptance. User acceptance, however, can be achieved only if the user has confidence in and thus accepts the reasoning process of the expert system. Therefore, it is important to evaluate not only whether an expert system is accurate but also whether its inference algorithm is appropriate and whether the answers provided can be justified by correct arguments. The output of the justification engine can then be used to assist users in understanding and learning about the reasoning process of the expert system. The present study of Garcia et al. (*2*) documents that their rule-based expert system provides the right answers for the right reasons. This documentation is an important prerequisite for a successful introduction of the expert system into clinical practice.

The present study of Garcia et al. (*2*) raises several questions that need to be elucidated in the future. The authors argue that the justification engine will help to improve the diagnostic performance of the expert system. This supposition is rather likely but needs to

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be proven. In addition, it is important to know how the justification engine is applied in daily use, how it affects less experienced physicians, and whether indeed it may make them more experienced. The impact of the expert system on daily clinical routines is clearly of interest. Further research needs to document how often physicians actually use the expert system and how often they use the justification engine. In addition, the question of how user acceptance is affected by inclusion or exclusion of the justification engine needs further exploration.

What are the possible implications of the present and previous studies of Garcia et al.? Central to their rule-based expert system is the codification of knowledge, problem solving, and a justification engine into a computer program. This format provides not only for easy distribution of the expert system by electronic means but also for multilingual implementation. Conceptually, it would not be difficult to use the framework of Garcia et al. (*2*) to deliver on the Internet a globally accessible, multilingual Web service. This service would enable nuclear medicine physicians around the world to evaluate the expert system and possibly assist in enhancing the diagnostic accuracy of diuresis nephrography. If this proposition sounds exaggerated or overambitious, one needs only to consider other areas in which a model of open knowledge sharing has been successfully embraced, such as the open-source software community.

Open-source software development, with its specific aims of collaborating on and sharing knowledge and information on the Internet, has enhanced software development and significantly increased value to users worldwide. An open-source model that has radically altered the distribution of knowledge and expertise in computer science may also be an effective means of advancing knowledge and diagnostic accuracy in nuclear medicine. In earlier work, Garcia et al. successfully used commercial models to distribute automated computer algorithms for analyzing myocardial perfusion scintigrams. In the more limited field of diuresis nephrography, an open-source model may be more appropriate for distribution and may reward the authors with global feedback and perhaps new avenues for improvement. Because open-source software distribution offers attractive features for sharing knowledge and improving quality, it is likely that it will be used more frequently for image processing and analysis in nuclear medicine.

At my institution, fewer than 3 diuresis nephrography studies are read per week. Therefore, it is conceivable that an open-source expert system for the interpretation of diuresis nephrography studies in combination with a justification engine that provides the right answers for the right reasons could be used to improve diagnostic quality—and this is what patients demand and deserve.

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