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EXPERT SYSTEMS: A NEW APPROACH TO RADON MITIGATION TRAINING AND QUALITY ASSURANCE

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Expert Systems: A New Approach to Radon Mitigation Training and Quality Assurance

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Training radon mitigators and ensuring that they provide high-quality work on the scale necessary to reduce radon to acceptable levels in the large number of homes and schools requiring some mitigation is a challenging problem. The U.S. Environmental Protection Agency and several states have made commendable efforts to train mitigators and ensure that they provide quality services to the public. Expert systems could be used to extend and improve the effectiveness of these efforts.

The purpose of this paper is to introduce the radon community to this promising new technology. The paper includes a description of a prototype system developed by Pacific Northwest Laboratory that illustrates several of the capabilities that expert systems can provide, a brief explanation of how the prototype works, and a discussion of the potential roles and benefits of fully-developed expert systems for radon mitigation.

INTRODUCTION

The number of radon mitigators that can be trained effectively and provided follow-up assistance for quality assurance using conventional training methods is limited. As with many knowledge- and skill-based activities, a period of hands-on apprenticeship is essential to develop proficiency. However, unlike most professions, few highly experienced radon mitigators are available to train apprentices, and the knowledge and experience in this field is rapidly changing. Expert systems could help fill these important needs in this field.

An expert system is a computer program that uses knowledge, usually captured in the form of heuristic rules, together with other information (facts) about the problem at hand to find (i.e., infer) solutions. Expert systems are particularly well-suited for tasks and decisions requiring knowledge held by a small number of persons (experts) or where the alternative is to follow a complex manual for guidance. Expert systems can also be used as training tools or to provide quick access to the most current information for a hot line service.

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Expert systems could guide radon mitigators step by step through the mitigation process, helping with diagnosis, selection of mitigation strategies, design and costing of specific installations (including identifying vendors for specific devices and materials), and providing recommendations at each step during installation. The advice provided would be based on expert knowledge incorporated in the system, along with site-specific information from observations and measurements and information on previous actions taken by the mitigator.

These systems would make state-of-the-art knowledge on radon mitigation, now held by relatively few experts, conveniently available to a large number of mitigation contractors. Widespread use of such systems would improve the quality of mitigation services generally available and would speed dissemination of new findings in research to practitioners in the field.

RADON MITIGATION ISSUES

In the United States, the Environmental Protection Agency (EPA), the Department of Energy (DOE), and several states have taken steps to address the problems associated with radon in buildings. Among other activities, the EPA has established a radon measurement proficiency program for laboratories and vendors of radon measurement services and, in response to legislation passed in 1988, has established three Regional Radon Training Centers (1). However, a number of important issues remain, which expert systems might help address:

- The number of homes and schools potentially requiring some level of mitigation is extremely large (possibly 12 million single-family homes in the U.S. alone), and a large force of radon mitigators will be required to provide the needed services. However, only a small number of mitigators can be classified as experts.

- Because each building is unique and factors influencing radon levels vary widely, correct interpretation of observations and measurements is complex.

- Without proper guidance and control, the number of contractors providing ineffective or questionable mitigation services to the public is likely to grow. This is currently addressed by training courses, guidance in publications, and evolving certification programs. However, only a limited number of contractors can be reached by training sessions, and follow-up support for mitigators is essential to ensure high quality mitigation.

- The EPA Technical Guidance (2) is sufficiently general (apparently by design) that agencies and contractors performing radon mitigation must use their own best judgment to make appropriate decisions about which mitigation techniques to employ for individual homes. Although the foremost authorities may have the ability to handle unusual situations when encountered, the average mitigator may not have the skill and ingenuity to make appropriate decisions without on-site guidance.

- Knowledge of radon mitigation is rapidly developing and changing. New information cannot be disseminated as rapidly as needed.

Well-designed expert systems that are easy to use and adaptable for field use could play a role in addressing these issues. Expert knowledge incorporated into an expert system could guide the mitigator in consistently making the best decisions--interpreting site-specific observations and measurements, developing mitigation strategies, selecting appropriate mitigation techniques, and installing mitigation measures--given the specific circumstances encountered while mitigating a home. Such systems could help bring the quality of the services provided by the average (and especially the novice) mitigator closer to that available from the very best mitigators. In addition, these systems could speed the dissemination of new developments from research to the field.

SYSTEM DESCRIPTION

A prototype expert system, the Expert Radon Mitigation Advisor (ERMA), has been developed at Pacific Northwest Laboratory. This system demonstrates several of the potential capabilities of expert system technology. It is not a fully developed system for field implementation. It implements part of the procedure recommended by Brennan and Galbraith (3), with some modifications (4), for selecting preferred mitigation techniques based on characteristics of a home.

ERMA prompts the user to enter information about the home ordinarily collected by a trained mitigator during a house inspection and diagnostic testing (see Figure 1). The information requested includes the radon measurement history in the home; the type of heating, ventilating, and air-conditioning equipment; the type of the building foundation; and other building characteristics that have a relationship to radon entry or affect potential mitigation techniques (2,3).

ERMA then decides which mitigation techniques are most likely to succeed, using the set of rules programmed into the system and the facts asserted based on information provided by the user. A representative screen from ERMA that presents the technique recommended most highly is shown in Figure 2; the particular technique listed in the figure was arbitrarily selected. The system selects the preferred method (independent of cost) based on the specific characteristics of each site and presents it first in a hierarchical list of alternative techniques in decreasing order of the strength of the recommendation. These alternatives are provided in the event that the mitigator prefers not to use the first technique for reasons other than those considered by the system (e.g., cost). The mitigator makes the final decision concerning which method to use. A fully developed system would then provide appropriate guidance for installing equipment and specifying materials and for installing, testing, and maintaining the technique selected.

Many of the capabilities that a fully developed expert system for radon mitigation could provide are shown in Figure 3. The system would be capable of answering questions that arise during the home inspection. The system would lead the mitigator through any diagnostic tests that are warranted prior to beginning mitigation and then through the process of installing the selected mitigation techniques. If unexpected problems were encountered during installation, the system would have the capability to recommend solutions to those problems. Once the initial mitigation measures are installed, the system would lead the mitigator through the process of testing the installation and then, if required, selecting and installing additional mitigation measures or modifying the initial installation. The expert system would also have the capability to document and provide explanations of all decisions.

An expert system could also be used to record case histories of all buildings treated by the users of the system. Widespread use might be coordinated to develop a statewide, national, or even international database of case histories; such a database could be used in mitigation research and to establish the performance of mitigation techniques and their applicability.

CONCLUSIONS

Our experience with the prototype ERMA indicates that radon mitigation advice can be provided logically and effectively using expert system technology. The prototype is based on limited knowledge presented in manuals and addresses only a small portion of the process of radon diagnosis and mitigation. However, it illustrates how expert systems might be used in this field to provide capabilities such as on-site mitigation assistance, training aides, and help in operation of hot lines. Expert systems could also play an important role in developing large case history databases. Fully operational systems will require considerably more development. Important development activities will include:

- eliciting the knowledge of mitigation experts and creating appropriate knowledge bases

- developing or selecting appropriate hardware systems for field implementation
- field testing by actual mitigators.

The technology, with further development, shows promise for helping address many of the problems associated with providing high quality mitigation services in a timely manner on the scale necessary to effectively reduce the total health risk from radon.

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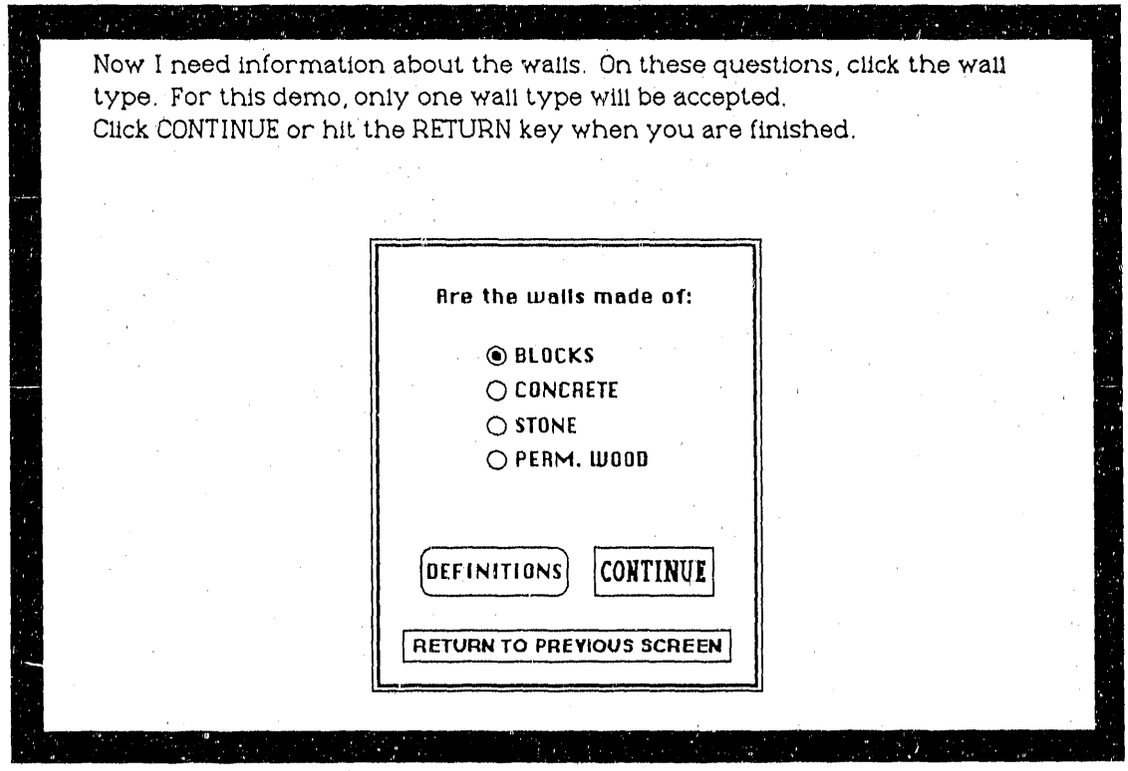

Figure 1. Representative ERMA data entry screen.

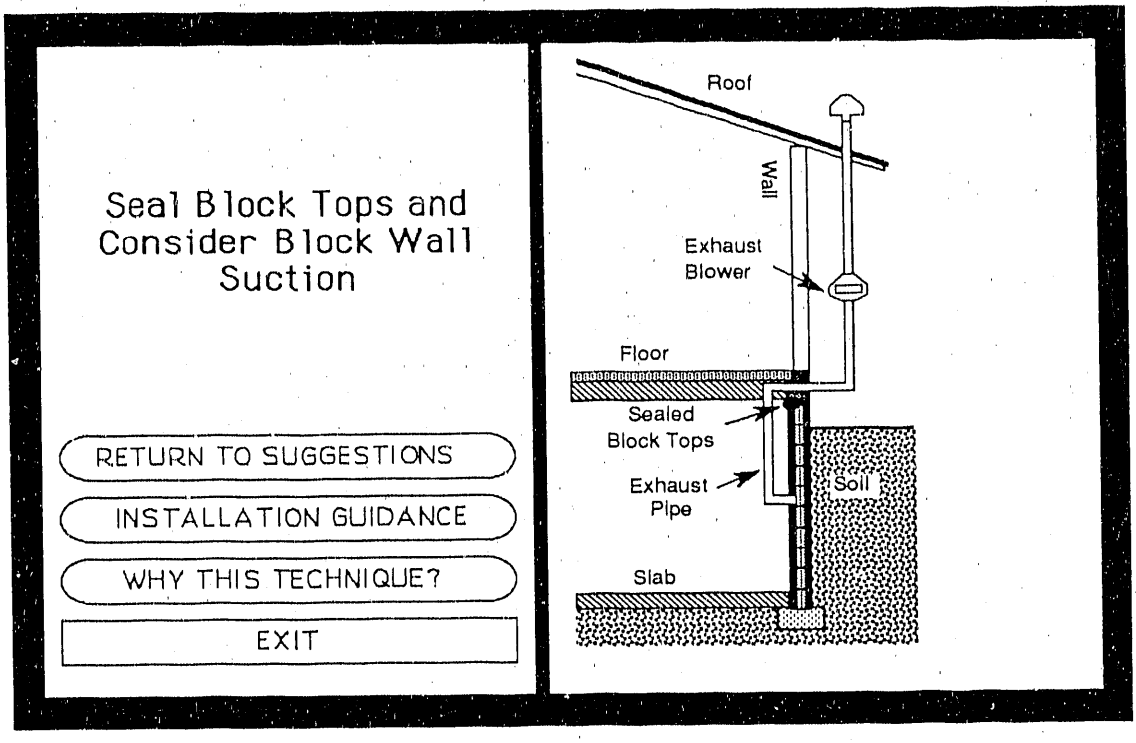

Figure 2. Example of an ERMA screen showing the recommended mitigation technique and a general diagram describing it.

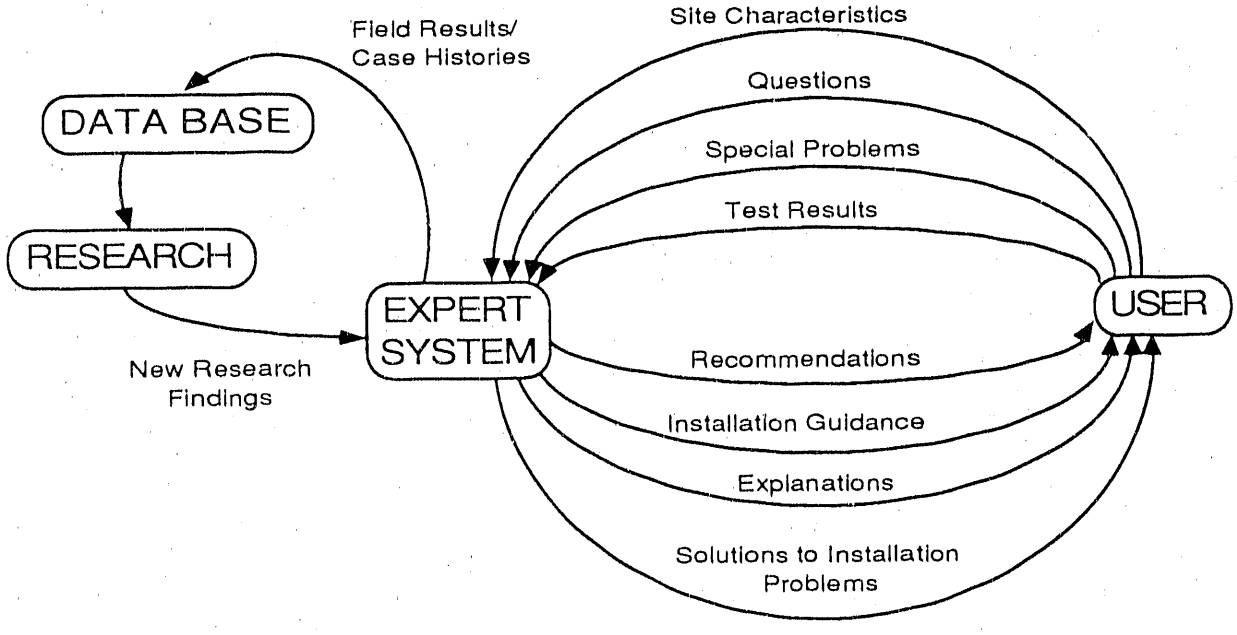

Figure 3. Some capabilities of a fully developed expert system for radon mitigation.

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