A STUDY OF TWO METHODS OF DELIVERING COMPUTER AIDED DIAGNOSTIC ASSISTANCE FOR TURF GRASS PROBLEMS ON THE WEB

Harlan Brewer, Utah State University, sonofkong@kellerits.com;
John Vinsonhaler, Utah State University, jvinson@b202.usu.edu;
Paul Johnson, Utah State University, paul.johnson@usu.edu

The demand for assistance for turf diagnosis far outstrips the availability of agricultural agents to offer this service. To meet this demand, thousands of Web Sites have been developed to assist with the diagnosis and treatment of turf grass problems. The two major types are Web Documentation Sites (DS's) and Expert Systems Sites (ES's). Documentation Sites consist of a library of relevant documents with a search engine. The user simply uses the search engine to find documents which will help with the problem. Expert Systems consist of a user interface, a computer readable knowledge base and an inference engine. The user answers questions about problem symptoms; this may include evaluating pictures of lawns with various problems. The Expert System then presents a description of the most likely problems and describes treatments. The purpose of this study was to empirically compare the diagnostic effectiveness of a DS with an ES for turf grass problems. Three groups were used—a control group, a DS group, and an ES group. The Control group received no diagnostic assistance. (The control was necessary since many people have developed some knowledge of grass problems in caring for their own or others' lawns). All groups attempted to correctly diagnose three common lawn problems. The DS group used five excellent Document websites to aid with the diagnosis. The ES group used a well-regarded Expert System. Diagnostic correctness was measured by rating the similarity of the participant's written diagnosis with correct diagnosis obtained from a Turf Grass expert. The mean diagnostic correctness of the DS group and the mean diagnostic correctness of the ES group were both highly significantly better than the mean diagnostic correctness of the Control group. There was no significant difference between the mean diagnostic correctness of either the DS or the ES group. If this result were to be supported by further research, the DS method might be effectively used in place of the much more expensive ES method. If an easy to use, highly effective search engine were provided in the DS it might yield better performance than any ES.

Keywords: turf grass, diagnosis, expert systems, Internet

THE PROBLEM

The problem addressed by this research is to provide low cost, readily available assistance with the diagnosis of turf problems for professionals and home owners. Turf grass is one of the largest crops in the country. There is an extensive need for expert assistance to professionals and the public with the diagnosis and treatment of turf problems.

In the past, public diagnostic assistance with turf problems has been mainly via personal contact with agricultural extension agents at universities and extension centers. Service is rendered by personal consultation by the agents and by publications provided by them. The problem is that there are too few turf experts while the cost involved in personal contacts with existing turf experts is very high. The Internet has largely changed all this. A Google search for

"Diagnosis Turf Grass Problems" currently yields about 5700 relevant Web pages. These include the following types.

Many sites simply provide on-line access to libraries of extension bulletins primarily from university extension units. They are maintained by extension sites. Some of these are excellent sources of information and include search engines for locating relevant information for particular problems. A second type of site sells books, pamphlets, and other materials relevant to turf problem diagnosis.

A third type of site sells diagnostic services from laboratories connected with universities or other organizations. These sites request the user to complete a form describing the turf problem and send a sample of grass and soil from his or her problem turf. The laboratory personnel run lab tests on the turf sample and use the results and the information on the user-completed form to diagnose the problems and inform the user.

A fourth type of site offers diagnosis and remediation advice based upon questions which users answer over the Web about the particular nature of their turf problems. These sites range from simple printed diagnostic diagrams provided to the user to elaborate systems which use information and images to systematically diagnose and remediate. These sites are maintained by companies which sell turf problem related products, such as herbicides and insecticides, and by university extension research centers.

PURPOSE OF THE STUDY

Table 1 compares the components of a typical expert system with the components of a typical web site research site. Note that the components of each are generally similar except that the Web Assisted system requires more user interaction in the diagnosis process and data collection.

Table 1: Comparison of Web Document and Expert System Assisted Diagnosis

Web Document Assisted Diagnosis	*Expert System Assisted Diagnosis (Turf Doctor)*
User Interface Provides • user selects keywords • user types keywords • user provides solution to diagnosis	User Interface Provides • expert system collects data about the problem from user • solution to the diagnosis is provided by expert system
Inference Engine • ordinary search engine of the web site pages	Inference Engine • processes user input and machine-coded knowledge base to obtain diagnosis
Knowledge Base • content of web page documents from the Web site	Knowledge Base • coded information associating user provided input with diagnosis problem

Vinsonhaler & Johnson (4) created the elaborate expert system called Turf Doctor and continue to provide it on the internet (http://knowledge.bus.usu.edu). Turf Doctor is a traditional Expert System that interviews the user by asking initial broad questions about the problem to locate the general class of problems, e.g., problems characterized by patterns on the grass. Next the system narrows the search to a specific set of causes and uses text and picture recognition to obtain a final diagnosis. A remediation is also provided. The entire diagnostic process is controlled and performed by the Turf Doctor using a Knowledge Base (a matrix of weights connecting symptoms with turf grass diagnostic problems) and an Inference Engine which uses the symptoms provided by the user to infer diagnoses using the Knowledge base. In this system we used one of the least complex methods—the Knowledge base was a set of records in a database, the Inference Engine was based on Case Based Reasoning. In general, expert systems for diagnosing grass problem are reported to be effective (1, 2, and 3).

As noted previously many valuable Web document sites are available. The five selected for this study are the following.

Table 2: Web Sites for Research

Web site URL	Organization
http://extension.usu.edu/publica/index.htm	Utah State University
http://www.ianr.unl.edu/pubs/horticulture/	University of Nebraska
http://www.ianr.unl.edu/pubs/plantdisease/	University of Nebraska
http://www.oznet.ksu.edu/library/	Kansas State University
http://www.agry.purdue.edu/turf/publicat.htm	Purdue University

Web Site Research Technique Summary

Using this tool to diagnose lawn care disease was based on the recommendation of Dr. Paul Johnson of Utah State University, an expert in the study of turf grass diseases. The essence of this technique is that an individual uses a beginning web site and its related pages to gather information that indicates the symptoms of possible lawn care diseases along with their related diagnoses. The user draws on the search engines inherent in these web sites for finding the data needed to assist in the diagnoses being completed. Of course, the participant may use a number of web sites and their related pages in the diagnostic process. In this research the participants were limited to a group of five specific web pages as indicated in Table 2.

METHODS

Participants

Forty-five subjects were drawn from the population of students at the Brigham City Branch Campus of Utah State University. These subjects were randomly assigned in groups of 15 participants to the control group and the experimental groups.

Experimental Design

In this study the independent variables were type of training and trial number. The dependent variable was Mean Rating of Diagnostic Correctness. The experimental design is shown in Table 3.

Table 3: Experimental Design--Participants were assigned randomly with out replacement to groups.

Group	Pre-Diagnosis	Trial 1	Trial 2	Trial 3
No Assistance	Instructions & Practice case Diagnosis	Counter Balanced Case Diagnosis	Counter Balanced Case Diagnosis	Counter Balanced Case Diagnosis
Web Page Assistance	Instructions & Practice case Diagnosis	Counter Balanced Case Diagnosis	Counter Balanced Case Diagnosis	Counter Balanced Case Diagnosis
Expert System Assistance	Instructions & Practice case Diagnosis	Counter Balanced Case Diagnosis	Case Diagnosis Counter Balanced	Case Diagnosis Counter Balanced

The inclusion of the *No Assistance* group needs comment. Many people in our population have some knowledge of lawn problems. Most home owners have lawns and, therefore, have periodic lawn problems. Many have used books and local retail sales persons for help with these problems. Further, in any group of undergraduate participants, there are a few who have had part time jobs working in garden stores. Therefore, we would expect that knowledge about turf problems is not necessarily zero for any given sample. Hence, a Control group is necessary to provide a base-line for knowledge about diagnosing turf problems.

Research Hypotheses

Two research hypotheses underlie the research. RH1 was that the diagnostic correctness of the three groups would be highest for the *Turf Doctor* Group, next highest would be the Web Document Group, and lowest for the *No Assistance* Group. The rationale was that Expert Systems had shown themselves effective in Turf Diagnosis, while the effectiveness of Web Document Sites was likely but unproven. RH2 was that the diagnosis correctness would increase over trials due to practice effects in using the technology.

Simulated Cases

Printed summaries of simulated cases were used for diagnosis. The cases were constructed by a turf grass expert and independently checked for validity. The included pictures of the problem Turf. In the Practice Case the problem was Slime Mold (a harmless mold using the grass leaf as a supporting structure). In the experimental cases the problems were Iron Deficiency, the Sod Web Worm (a caterpillar which consumes grass leaves), and Necrotic Ring Spot (a disease attacking grass roots).

Training

Training time was kept to a limited 5 minutes under the assumption that adding extensive training, usually offered to users of Expert Systems, would not be representative of the experience of the ordinary Web user. We assumed that the Web user of both systems would have to, in part, learn for themselves how to use the assistance offered.

Diagnostic Correctness

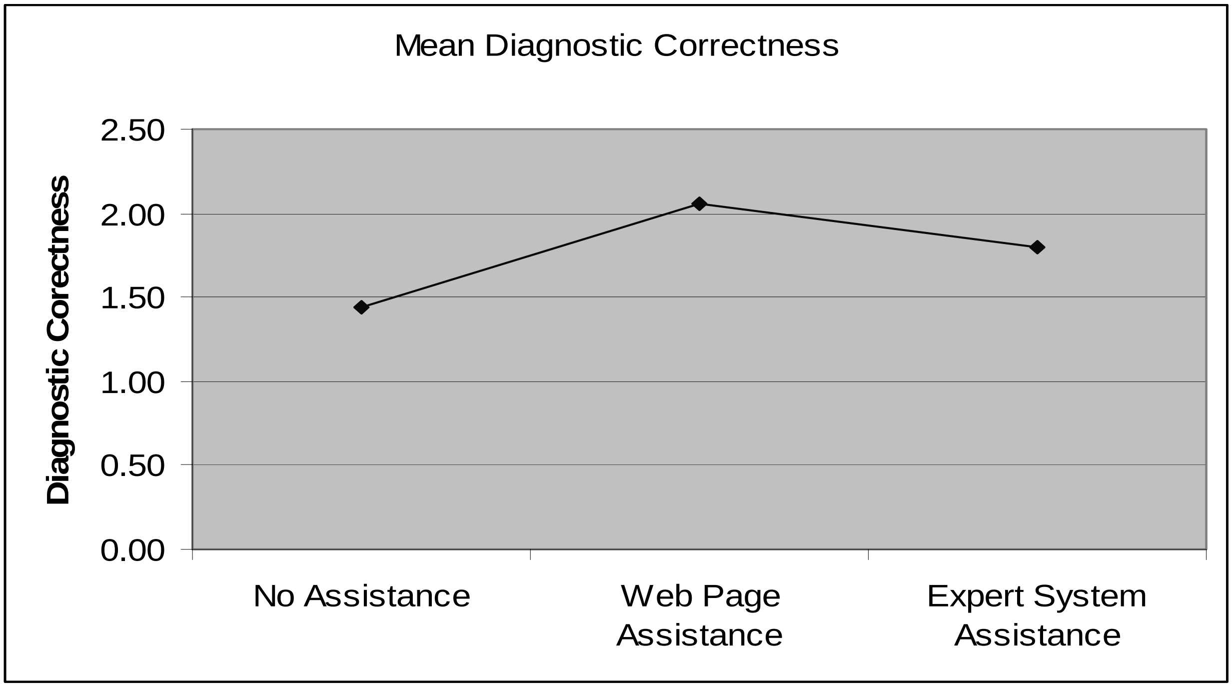
Ratings of the diagnostic corrections of participant's written diagnosis for each of the three test cases were assigned independently by two judges using the rating scale given below. A score of 3 was assigned to the participant's diagnostic statement if it exactly matched the correct diagnosis (Iron Deficiency, Sod Webworm, Necrotic Ring Spot) A score of 2 was assigned if the statement matched the general problem (lacks nutrient, insect problem, disease or fungus). A score of 1 was given for anything else.

RESULTS

Effects of Treatments

The results for RH1 (that the mean correct diagnosis rating would be best for Turf Doctor, next for Web Documents, and last for *No Assistance*) are summarized in Figure 1 and Table 4 below. As may be seen from Figure 1, both of the assistance groups performed better than the *No Assistance* group, but the Web Document group did better than the Turf Doctor group. One interesting finding is how well the *No Assistance* group did. A failure to give any relevant diagnostic statement received a rating of 1.0, but the *No Assistance* group had a mean of nearly 1.50, suggesting that some of our participants knew something about turf diagnosis.

Figure 1: Mean Diagnostic Correctness for the Treatments



The ANOVA results confirm the statistical significance of the treatment group effect at the .00 level of confidence level (F Statistic 5.8 P< .007).

Table 4: ANOVA Effects of the Three Treatments

Source	Type III S Squares	*df*	Mean square	*F* statistic	Significance
Group	6.796	2	3.398	5.876	.007
Error	19.083	33	.578		

The differences between means were tested for significance with t-tests. The differences between the means for the *Assistance* groups and the *No Assistance* groups were significant at the 02 level of confidence (t-test Web Document vs. *No Assistance* was p<.002 and t-test *Turf Doctor* vs. *No Assistance* was p<.02) The differences between two *Assistance* groups was not significant (t-test Web Document vs. Expert System was p>.25)

Effects of Practice

RH2 (that performance would improve across trials) was not confirmed. The diagnostic correctness remained approximately the same across all trials. In the ANOVA, the main effect of trials was not significant at the .05 level of confidence (F = 1.75 P >.195).

CONCLUSIONS

Both types of diagnostic assistance yielded higher diagnostic correctness than the control treatment as might be expected from the literature. However the control group gave many diagnoses which were correct with respect to the general problem, e.g., insect, disease or lack of nutrient. This may indicate our participants knew something about grass.

The Web Document sites yielded non-significantly higher diagnostic correctness than the Turf Doctor System site. The failure of the Expert System may be due to the lack of the training usually given to users of expert systems. Also those using the Web Document sites probably have had extensive experience in locating information with a search engine.

These findings suggest an implication for the domain of Web assistance to the diagnosis of turf problems on the Web. The problem with expert systems is the cost of the effort required to create them versus the cost of a Web Document site. We might generate a system more cost effective than ether the expert or document site by combining a more intelligent search engine, commonly used in Expert Systems, with Document Assistance sites. For example, we could provide the user with a search engine which provided a list of turf problems with short descriptions and then pass those selected by the user to a standard search engine which would locate sites containing the key phrases.

In our view learning did not occur over trials for two reasons—repeated trials over the same case(s) did not happen, and no corrective feedback was given between trials. Learning does not appear to be attributable to simply using the technologies.

REFERENCES

1. Fermanian, T. W., & Michalski, R. S. (1989). Weeder: An advisory system for the identification of grasses in turf. *Agronomy Journal, 81,* 312-316.
2. Liu, H., Fermanian, T. J., & Carmer, S. G. (1991). Expert system for planning the establishment of turfs. *Agronomy Journal, 83,* 140-143.
3. Voigt, T.B., Fermanian, T. W., & Sullivan, W. C. (1998). Selecting Kentucky bluegrass cultivars. *Crop Science, 38*, 1035-1041
4. Vinsonhaler, J. F., & Johnson, P. G. (2001). Turf Doctor: A web-based expert system for turfgrass problem diagnosis and treatment. *International Turfgrass Society Research Journal, 9,* 3-7.