Expert Systems Approaches for Decision Support in Health Care

(Health Care Track)

Mohamed EL Etribi

Southern Illinois University, 38 Timbercrest Lane, South Setauket, NY 11720

[1]The use of Expert Systems (ES) in the delivery of health care is receiving greater attention due to factors such as constrained budgets, staff turnover, and increased malpractice suits. Specific ES was developed by the author. A questionnaire, which covered the twenty possible CLIA'88 codes was developed and sent to three hundred evaluators. Eighty-six valid responses were received and analyzed. The experimental results support the incorporation of ES into the present health care delivery. It suggests that ES may have wider applications in health care
(Expert Systems, Decision making, and Health Care)

1. Introduction

Clinical laboratory testing is an important part of patient care. The Clinical Laboratory Amendment (CLIA'88) was enacted to assure that Americans receive high quality, and reliable testing in Laboratories of all types and sizes throughout the nation. CLIA'88 personnel standards require specific skills and knowledge for Laboratory workers that vary due to the complexity of tests performed.

The study will examine the use of Expert Systems (ES) technology for cytology personnel evaluations according to CLIA'88 regulations. The author, using a commercially available package developed specific ES. After a sequence of preliminary tests of the ES system, the final version was deemed valid. A questionnaire of fifteen different cases, which covered, the twenty possible CLIA '88 codes (four technical supervisors, two general cytosupervisors, eight cytotechnologists, and six unqualified codes), was developed. This questionnaire was sent to three hundred evaluators in the field of medical technology. Eighty-six valid responses were received and analyzed.

2. Expert Systems

An Expert System (ES) is a computer program that contains extensive knowledge about a specific narrow, real world domain. ES emulates human experts in solving problems. ES attempts to solve domain-specific problems using strategies or heuristics to produce a logical sequence from data and expert derived facts.

ES is used in the fields of medicine, engineering, business, geology, tax analysis, and law (Hicks & Lee-1988). Such systems are being successfully utilized to diagnose illness, analyze structure, train personnel, and recommend strategies.

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[1]The author chose VP-Expert shell 3.0 (Professional Version) for the cytology personnel classification problem. It is an expert systems development tool. VP-Expert shell contains commands that allow it to explain its actions during a consultation. VP-Expert shell is one of the higher rated and least expensive shells (Brody-1989). It enables developing systems in a language very close to plain English and it is useful in working with non-technical people.

3. Research Framework

The cytology personnel evaluation model is presented in Figure 1. The figure shows input, process and output phases. There are eight inputs into the CLIA'88 cytology personnel qualifications: education, experience, training, degrees, boards, technical supervisor's delegation, licenses, and dates of employment. The outputs are four technical supervisors codes, two general cytosupervisors codes, eight cytotechnologists codes, and six unqualified codes. The personnel evaluations were carried independently by the ES, by the Human Experts (Credentials Agency Evaluators), and by the Users (Clinical Laboratory Evaluators). An explanation of the model variables follows:

A. Input

The input consists of the applicant's qualifications. It contains eight different categories according to CLIA'88 Regulations.

Education – There are different education requirements. The education requirements range from high school, Associate degrees, Bachelors, Masters, Doctorates, and Medical degrees

Experience – This includes pre-experience and post-experience. Experience ranges from six months to twenty-four months for pre-experience qualifications. For post-experience qualifications, the applicant must have more than thirty-six months to be qualified as a general supervisor.

Training – This includes less than six months, from six months to less than twelve months and twelve months or more. Training must be done in approved clinical laboratories to be accepted toward personnel evaluations.

Degrees - These include passing CAHEA-accredited school of cytotechnology, certifying in cytotechnology by approved Health and Human Service agency (HHS), and passing the HHS examination.

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[1]**Board Certification** – The success in the board certification is required in order for the applicant to be qualified as a technical supervisor. There are three board certifications:

    a. American Board of Anatomic Pathology
    b. American Board of Clinical Pathology
    c. American Board of Cytology

Delegations – An individual, in the final year of training program leading to certification, must obtain delegation from the technical supervisor in order to be approved as a technical supervisor.

Licenses – Some states issue licenses for cytotechnologists and/or cytosupervisors. The applicant must obtain such licenses to be considered for approval as technical cytology personnel.

Dates of Employment – Applicants, who held a job before January 1, 1969, have different requirements than those held jobs after December 31, 1968.

B. Process:

The applicant's qualifications were introduced to ES. Human Experts and Users also evaluated the same qualifications.

C. Output:

The ES, Users, and Human Experts competed in evaluating cytology personnel according to CLIA'88 regulations. There are twenty codes (fourteen approved codes, and six unapproved codes). The success or lack of success in cytology personnel evaluations is used to determine the score of each system. The differences in evaluations between these systems were analyzed.

4. The Cytology Expert System

A Knowledge-based System (KBS) that evaluates the technical personnel according to CLIA'88 regulations was developed and tested. This ES assigns codes depending on the applicant's credentials and licenses. ES will show the reasons for the evaluations.

The general area under study is identifying the technical personnel codes according to CLIA'88 regulations. There are ninety-three different codes for the technical personnel working in clinical laboratories.

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[1]The applicant qualifications are introduced to ES step by step. The module will ask questions and the users will give responses. According to the information given by the user, the ES system will evaluate the cytology personnel into fourteen qualified codes and six unqualified codes. The ES will explain how it arrived at decisions upon request.

ES contains five modules. The author verified, validated and tested every KBS individually and collectively on several levels. The cytology personnel evaluations made by the ES were then compared with the actual evaluations carried by Human Experts.

A. The Credentials Module

The credentials module contains nine production rules. It evaluates the completeness of the applicant's credentials according to education, training, and experience.

B. The License Module

The License module is constructed of fourteen rules. It matches the state's license requirements with the applicant's license.

C. The Technical Supervisor Module

This module contains seven production rules. It evaluates the applicant according to their medical degrees, permits, professional boards, training, and delegations from any approved technical supervisor. This system's module identifies the four technical supervisors'codes.

D. The Cyto 5 Module

This module contains nineteen production rules. It coded the applicant according to education, experience, training, professional examinations, technical supervisor evaluations, and Cyto-requirements status. Eight cytotechnologist codes and one cytosupervisor code are identified in this module.

E. The Cytosupervisor Module

This module contains three production rules. This module evaluates the technical personnel according to the applicant cytotechnologist credentials, cytosupervisor job held, and the applicant post-experience. It identifies one cytosupervisor code.

F. Expert System Connectivity

Due to the complexity of the personnel requirements, the author used two types of connections in designing the Expert System. Modules and rules connections were used.

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¹. Modular Connections

The author made connections from the credential module to the license module to the technical supervisor module to the Cyto 5 module, and ended in the cytosupervisor module. All the information is saved and transferred to the next module by using the commands embedded in the VP-Expert professional shell.

. Rule Connections.

These connections enable the system to exit when the evaluation is completed. For example, ES ends the evaluation in the credentials module, if the applicant has a foreign education.

5. *Discussions and Analysis*

Three hundred questionnaires were sent to users (clinical laboratory personnel), and human experts (credentials agency evaluators). Eighty-six valid questionnaires were received and analyzed. Each questionnaire contains fifteen cases with twenty codes. The scores of the personnel evaluations for each group were obtained. The 95% confidence intervals for users and human experts were calculated. Since Expert system has 100% precision, only the score was calculated.

There are two areas in which the results will be interpreted in this paper. The first will be the examination of the performance of ES. The second area will be the comparison of the performance of ES with the performance of Humans.

A three level scoring system of the value evaluation entities is:

      a. Correct assessment is given the score of three
      b. Underassessment is given the score of two
      c. Overassessment is given the score of one

The reason that the score of overassessment is lower than underassessment is due to the greater danger of entering unqualified personnel in the cytology field. On the other hand, underassessment will not cause any harm to patients.

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[1]Comparison of ES, Users, and Experts

Evaluators	Unqualified Personnel	Cytotechnologists	Cytosupervisor And Technical Supervisor	All Personnel
	(6 Codes)	(8 Codes)	(6 Codes)	(16 Codes)
ES	1.00	0.75	0.75	0.84
Users	0.66	0.59[*]	0.62	0.61[*]
	(0.6 – 0.72)	(0.55 – 0.63)	(0.58 – 0.66)	(0.57 – 0.65)
Experts	0.69	0.80[*]	0.64	0.66[*]
	(0.65 – 0.73)	(0.76 – 0.84)	(0.59 – 0.69)	(0.62 – 0.70)

* 95% Confidence

From the above table, the cytology expert system (ES) performs better than the users and experts for all the cytology personnel evaluations. As shown in the above table ES score 0.84 against users score of 0.61, and the experts score of 0.66. The evaluations of experts are better than users. Experts tend to solve more complex decisions than users because of their more intensive training in personnel evaluations.

6. Conclusions and Future Research

The results of this study showed that ES made more accurate and consistent assessments than human experts and users. The findings can be generalized and then can be applied to the 300,000 technical laboratory personnel evaluated yearly according to CLIA'88 regulations. The ES program can also be expanded to cover similar situations where personnel evaluations or any complex classification problems are required (Dologite and Mockler-1995).

The advantages realized from the cytology Expert System are:

      A. It increases the efficiency of carrying out CLIA'88 regulations by decreasing the time that humans spend on this knowledge and labor intensive, yet routine task.

      B. It enhances consistency in decision-making, increasing both the accuracy and precision of personnel evaluations.

      C. This prototype can be disseminated to all CLIA'88 personnel. This could save tens of million dollars annually.

      D. The utilization of Expert Systems can be expanded to any classification and pattern recognition problems. ES will make contributions to any multiple-criteria decision-making problem.

      E. This program can be served as a training tool for new evaluators.

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[1]Several enhancements to this Artificial Intelligence system can be developed to make it more useful. One would be to provide access to databases of all personnel evaluations to all accrediting agencies and clinical laboratories upon request. Another enhancement is to network this system throughout the users. Due to the networking, the system can update its record instantaneously.

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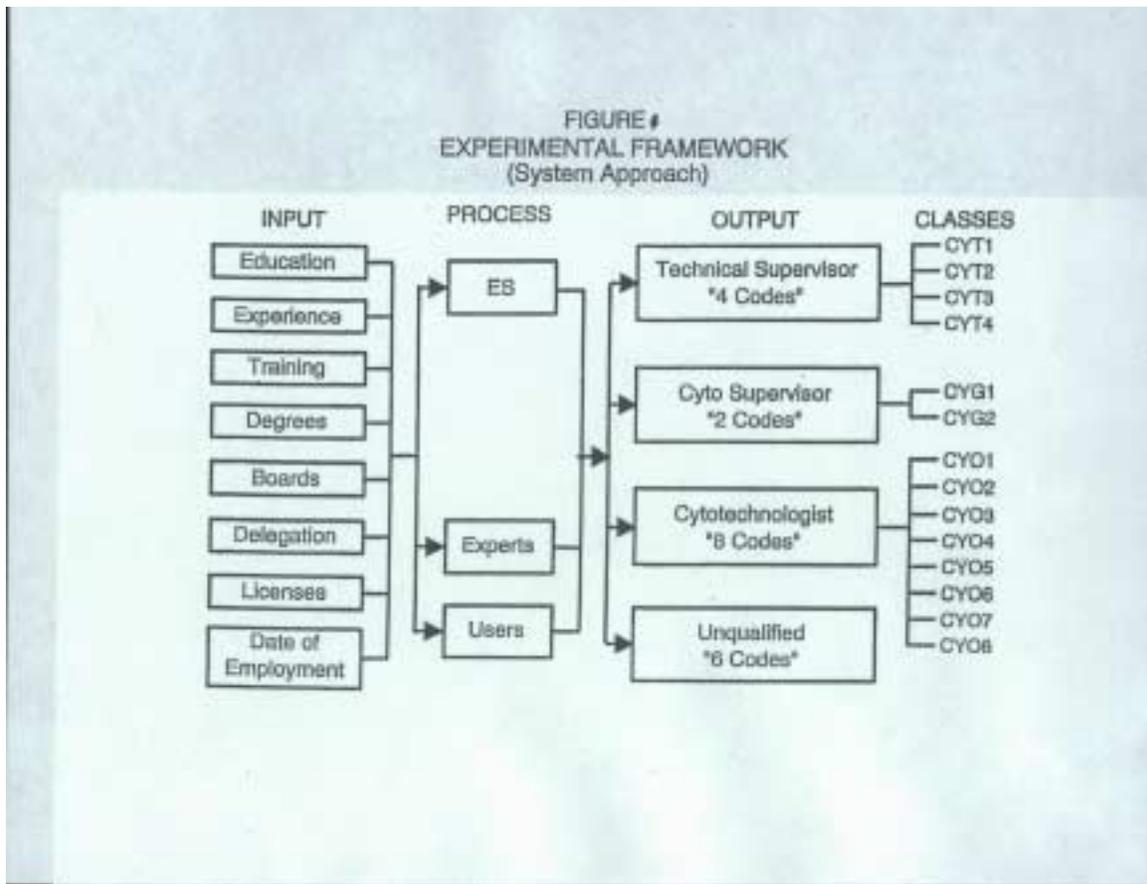
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FIGURE
EXPERIMENTAL FRAMEWORK
(System Approach)

INPUT	PROCESS	OUTPUT	CLASSES
Education	ES	Technical Supervisor "4 Codes"	CYT1 CYT2 CYT3 CYT4
Experience			
Training		Cyto Supervisor "2 Codes"	CYG1 CYG2
Degrees			
Boards		Cytotechnologist "8 Codes"	CYO1 CYO2 CYO3 CYO4 CYO5 CYO6 CYO7 CYO8
Delegation	Experts		
Licenses			
Date of Employment	Users	Unqualified "6 Codes"	

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