Article *NIMHANS Journal*

Expert System for Dementia / Depression Diagnosis

Volume: 14 Issue: 02 April 1996 Page: 99-106

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Abstract

Differential Diagnosis of dementia and depression requires expertise. DAD is a computer-aided expert system, which uses the patient's behavioural, cognitive, emotional symptoms; and results of neuropsychological assessment to diagnose depression or dementia. Built in Turbo Prolog, it uses depth first search method with backward search strategy. DAD's knowledge base has three data bases. Problem is represented with the problem reduction method using four modules. Results from the four modules are combined to give a final outcome which is then compared with facts in the knowledge base. DAD diagnoses the case on the basis of this match. DAD was validated on four patients' records. DAD's diagnosis coincided with the treating team's in each case.

Key words -
Dementia,
Computer-Assisted Diagnosis,
Differential diagnosis,
Depression,
Expert systems
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Computer-Assisted Diagnosis,
Differential Diagnosis,
Depression,
Expert systems

Expert systems are computer systems that mimic an expert's thought processes to solve complex problems in a given field / domain [1] The expert systems Neurex and Neurdogist-I help in diagnosis of diseases of the nervous system [2]. Epilepsy Expert is an expert system for diagnosis of epilepsy and sleep disorders [3]. Expert systems are useful when decisions are based on multiple facts, which have to be simultaneously borne in mind. Expert systems being built on the expertise of an expert(s) of the field, becomes available to a large group.

Differential diagnosis of depression and dementia is a difficult problem. Symptoms overlap between the two conditions, making differential diagnosis difficult. A misdiagnosis may often lead to irreparable losses. hence the plan for developing a computer system which can diagnose the disease efficiently and ease the job of diagnosis for a psychologist/ psychiatrist/neurologist was thought of. The present study describes the development of an expert system to diagnose depression and dementia (DAD) and is based on the expertise of a clinical psychologist, i.e. the second author.

DAD is an expert system to be used by the clinician. The patient's symptoms and neuropsychological findings are fed into the computer and the diagnosis is given by the computer. This expert system assumes that, the patients have been already seen by a neurologist or psychiatrist who would have entertained diagnosis of depression/dementia. the expert system diagnoses whether the referred case has depression or dementia. DAD is a preliminary attempt in this direction.

Material and Method

Apparatus

IBM compatible computer - PC, PC / XT, PC / AT having 640K RAM, a hard disc and MS-DOS operating system is required. TURBO PROLOG is the computer language used to build this expert system.

Design

DAD was written using the Artificial intelligence language TURBO PROLOG, which is a logic based language, using predicate calculus to represent the knowledge. It has built in depth first search method with backward search strategy. Diagnosis was based on the case history elicited by the treating team and neuropsychological findings. User has to key in these details to the computer as and when the computer asks in predefined way. E.g.: one of the questions computer asks is "appearance neat/ unkempt (n or u)", user has to type 'n' for neat and 'u' for unkempt. Another such question is - "Crying spells present / absent (p or a) " user has to type "p" if crying spells are present and 'a' if absent. In this way the computer takes all necessary data from user.

Knowledge Base

Heart of any expert system is the knowledge base. The knowledge base has three parts i.e., Databases, production rules, and working memory [4]. DAD's knowledge base has 3 databases, which tap information form case history, clinical observation and neuropsychological assessment. Database 1 has 8 variables and 384 facts. The first 7 variables pertain to details regarding appearance; appetite; sleep; weight change over past few months; social functioning; occupational functioning and family interactions of the referred case. Eighth variable is the finding based on these 7 variables. Each of the 384 facts represents a combination of first 7 variables. The facts looks like this "If referred case is neat in appearance, has poor appetite, inadequate sleep, there is change in body weight, social functioning is impaired, occupational functioning is adequate, family interactions are impaired then he / she is surely mentally ill". When a case is referred, the fist 7 parameters are fed to the computer on the basis of patient's symptoms. i.e. computer asks questions and the user keys in the answer in the manner already described. computer system then searches back (backward search) [4] to find with which of the existing 384 facts does its first 7 parameters match. After it finds one, it returns to the 8th parameter, i.e. the matching fact. Depending on this finding the referred case is categorised as 'Surely ill', 'doubtfully ill' and 'not ill'. If the outcome is 'surely ill', programme proceeds to data base 3 directly. If outcome is 'doubtfully ill' it proceeds to data base 2.

Database 2 has 5 variables and 16 facts. First four variables pertain to the presence or absence of emotional disturbance, cognitive disturbance, inter personal stressors, significant life event. Fifth variable is the finding based on first 4 variables returned by the computer. The case is classified as 'surely ill', and "not ill" as per the outcome. If the outcome is "surely ill", programme proceeds to database 3.

Database 3 has 5 variables and 252 facts. The first 4 variables are results from the 4 modules (sub programs). The modules examine the nature of emotional disturbances, cognitive disturbances, cognitive disturbances, behavioural disturbances and neuropsychological test results. The fifth variable consists of the final result based on first 4 variables. Similar to database 1, in database 2 and database 3 also the facts are decided by the expert and they represent combinations of variables pertaining to that database. The computer searches for a match between one of the facts and the patient's symptoms in database 1 and 2. In database 3 the computer searches for a match between one of the facts and the results/combination of results of subprograms 1, 2, 3 & 4. Searching for a match is, as before by backward searching.

The computer uses production rules to take the variables, to put them in proper way, to take decisions and to maintain flow of control. Working memory is the area in the computer where the manipulation of knowledge takes place.

DAD's problem is represented using problem reduction method i.e., divide the main problem into as many sub problems as possible, so that each of the sub problem can be tackled independently and more easily. DAD has 4 subproblems (or subprograms or models). First subproblem deals with the problem of emotional disturbance. Second with that of cognitive disturbance. Third with the behavioural disturbance and fourth sub problem gives the result of neuropsychological test. These are the divisions used as the first four variables of Database 3. Each subproblem works on the basis of a branching tree, a tree which depicts the flow of logic used by the expert. In searching for the solution each subproblem employs a search strategy. Here, in this expert system, depth first search strategy is employed, i.e. system takes on one branch of the tree at a time, searches downwards in that domain, till either a dead end or a solution is reached.. If a dead end is encountered, then it traces the next alternative unsearched branch in the same main. No heuristic function is employed here.

Flow of databases in DAD

Sub problem - 1 (module 1) - Emotional disturbances

This subproblem tests the nature of emotional disturbance of the referred case. The branching tree has two main stems, main 1 and main 2, which are pictorically depicted in Figure 2.

Branching tree of sub program 1 - emotional disturbances module (P-present; a-absent; dep or dem-depression or dementia; not dep or dem-neither depression not dementia)

The variables E1 to E8 depicted in Figure 2 are described in Table I.

Table I - Variables and their descriptions of emotional disturbances module

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Here as said before, depth first search strategy is used in both the main 1 and main 2 of Figure 2. To illustrate the search method, eg. in main 1, program checks whether "crying spells are present or absent". If crying spells are absent, then the right side of main 1 is traced downwards. If 'crying spells are present', then only left side of main 1 is traced downwards. Say here 'crying' spells is absent. There

system checks for the presence or absence of 'crying spells and feeling of helplessness or crying spells and feeling of hopelessness or crying spells and feeling of worthlessness'. If any one of these three symptoms is present then the finding is 'the referred case is either depressed or demented emotionally'. Since a solution is reached, program stops searching in main 1 and starts searching in main 2.But, if E2 is absent i.e., if all the three symptoms are absent, then system checks for presence or absence of E1 i.e., 'crying spells and feeling of helplessness' and 'crying spells and feeling of hopelessness' and 'crying spells and feeling of worthlessness'. If present result is 'depression or dementia'. If any of the above three symptoms is absent then it is neither depression nor dementia. In the same way, a conclusion is reached at main 2. The result from main 1 and main 2 are tabulated to get one final result from this subprogram. Table II describes the result from the subprogram 1.

Table II - Result of emotional disturbance module

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Subprogram 2 (module 2) - Cognitive disturbances

This subprogram examines the nature of patients cognitive disturbances in the areas of memory, concentration, orientation and insight as perceived by him or by the informant. Branching tree has two mains - main 1 and main 2 and checks on 10 symptoms of the patient. It has variables C1 to C10. Depth first search strategy is adopted in each main to find the solution. Results from two mains are tabulated to arrive at one final result for subprogram 2. Branching tree and symptoms are given in figure 3, and Table III respectively Table IV gives the result of this module.

Branching tree of subprogram 2- cognitive disturbances module

Table III - Variables and their descriptions of cognitive disturbance module

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Table IV - Result of cognitive disturbances module

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Sub program 3 (module 3) - Behavioural disturbances

This subprogram examines the nature of behavioural disturbances. It has a branching tree with 4 mains - main 1, main 2, main 3 and main 4. there are 20 variables, named B^1 through B^{20}. Depth first search is adopted. Each main yields one result. The four results from four mains are tabulated to get one final result for the subprogram 3.Details are given in Figure 4, and Tables V and VI.

Branching tree subprogram 3 - Behavioural disturbances module

Table V - Variables and their descriptions of behavioural disturbances module

Table V - Variables and their descriptions of behavioural disturbances module

Table VI - Results of behavioural disturbances module

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Subprogram 4 (module 4) - Neuro psychological deficits

This module examines the nature of neuropsychological deficits. The battery used for testing is NIMHANS neuropsychology battery [5] which is used or day-to-day clinical use in the neuropsychology unit of the Department of Clinical Psychology, NIMHANS. The neuropsychological battery follows the ideometric approach; and is based on clinical observation as well as tests. Dysfunctions of attention, motivation, expressive speech, ideational fluency, abstraction, delayed response learning, visual scanning and personality disturbances indicate frontal lobe deficits. Dysfunctions of visuo spatial perception, visuo constructive ability, presence of agnosias, apraxias, body scheme disturbances and hemineglect indicate parietal lobe deficits. Dysfunctions of verbal comprehension, visual integration, verbal and visual learning and memory indicate temporal deficits [6]. The battery was validated against C.T. scan and operative findings on neurosurgery patients [7]. Branching tree has only one main, depicted in Figure 5. Subprogram 4 cheeks on 13 variables namely N1 through N13 (Table VII). Depth first search is used. One result emerges from the tree i.e. if NI is present it is depression or dementia; N2 or N3 is present it is dementia; N4 to N13 any one is present it is dementia; N4 to N13 all are absent then it is not dementia.

- ***Branching tree for subprogram 4 - Neuropsychological disturbances module***

Table VII - Variables and their descriptions of neuropsychological deficits module

Table VII - Variables and their descriptions of neuropsychological deficits module

Finally the results from subprogram 1, subprogram 2, subprogram 3 and subprogram 4 are compared with the already defined facts of database 3. When the first four parameters of a fact matches with the results from these four subprograms, the fifth parameter of the matching fact is declared as the final result. Figure 6 shows the 'Flow chart' of the expert system.

- ***Flow chart of expert system***

Validation

Validation has been done on four cases, taken from neurology and psychiatry department of NIMHANS, Bangalore. Treating team made the diagnosis as per ICD 9 [8]. The diagnosis by the system is based on the case history elicited by the treating team and neuropsychological test report from neuropsychology unit. Case 1 was a 75 year old married male agriculturist with 4 years of schooling, from middle socioeconomic status came with a history of decreased sleep, feeling sad, poor memory and decreased psychomotor activity. The patient was disoriented to time and had no insight. Neuropsychological assessment had revealed diffused involvement. The treating team's diagnosis had been senile dementia. Expert system diagnosed the case as dementia.

Case 2 was a 60 year old married male; illiterate and agriculturist by profession from low socio economic status. Patient was a known hypertensive since 8 years and was on regular medication; he came with a history of forgetfulness. Insight was absent and disorientation to time was present. Neuropsychological assessment had revealed fronto temporal deficits. The treating team's diagnosis had been Hypertension with multi-infarct dementia. Expert system diagnosed the case as dementia.

Case 3 was a 53 year old married male; illiterate and a cook by profession from low socio-economic status; with a history of alcohol dependence. Patient had presented with complaints of inadequate sleep, poor appetite, decreased interest in work, wandering tendency, feeling sad, irritability, crying

spells, poor memory, lack of insight and restlessness. Neuropsychological assessment had revealed diffused involvement. The treating team's diagnosis had been presenile dementia. Expert system diagnosed the case as dementia.

Case 4 was a 64 year old married male with 6 years of schooling and had retired from defence service. Patient had presented with complaints of inadequate sleep, sustained sadness which increased in the mornings, poor memory, decreased psychomotor activity, loss of interest in activities, being with drawn. Neuropsychological assessment had revealed fronto temporal deficits. The treating team's diagnosis was presenile dementia. Expert system diagnosed the case as dementia. In all the four cases expert system's diagnosis matched with that of the treating team's diagnosis.

DAD is the first version of this expert system. The subsequent revisions would utilize a greater knowledge base as well as a larger sample for validation.

Acknowledgements

We are grateful to the Departments of Neurology and Psychiatry, NIMHANS, Bangalore for their cooperation.

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