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Research paper

Expert system for building cognitive model of a student using 8-puzzle game and for career assessment

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Abstract

Career assessment is useful for a student in order to know the suitable jobs for him/her in future basing on student's knowledge memory power, Intelligence, psychological aptitude, etc. During the academic program of a student, it is very important to assess the appropriate career(s), so that a student can select some appropriate electives and some specialized subjects, which lead to an appropriate career(s). In the process of academic program of a student, it is highly essential to plan his/her career. Generally, the career counselor in an institution analyzes the student's academic record/Cumulative Grade Point Average (C.G.P.A.) and predicts suitable career(s) in industry. In case of students belonging to Computer Science and Engineering branch, counselor will suggest some appropriate jobs in software industry viz. software designer, software engineer, tester, marketing person, etc. based on the academic record. Apart from academic record, one should also consider the student's psychological factors like intelligence, problem solving ability, patience, etc. to predict a better career. We developed an expert system for predicting career by assessing psychological factors of a student like problem solving ability, intelligence and patience levels of a student. In order to assess these psychological factors, we developed 8-puzzle game to assess student's intelligence and planning ability levels, fastness in playing game, and patience levels. The system requests the student to play 8-puzzle game many times and displays the scores of student. A career table is designed which consists of list of careers in software industry and the minimum levels of requirements in academic record, intelligence, patience, etc. The academic record and psychological factors of the student are compared with the minimum levels required for each career and thus the system predicts the matching career(s) for the student.

Keywords: *8-Puzzle Game; Game Playing; Assessing Psychological Factors; Cognitive Model; Career Assessment; Expert System; Intelligence; Patience and Perseverance; Speed of Problem Solving; Learning Abil1. Semicolon.*

1. Introduction

1.1. Career assessment

There are many ways to assess the Intelligence of a student that include Aptitude and Reasoning tests, IQ tests etc. Other than these methods, Intelligence can also be assessed while playing a game with a computer. An expert system for career assessment can identify the suitable careers for a student basing on a cognitive model of the student. The cognitive model comprises of various psychological factors viz. Intelligence, Patience and perseverance, speed of solving problem, Learning ability etc. A Student can play a game with an expert system and the system can assess the psychological factors of the students. By playing 8-puzzle game, assessing psychological factors becomes easy. A career assessment system (expert system) can suggest suitable career(s) that suit a student.

1.2 8-puzzle game

Intelligent games can be used to assess the psychological factors of a player (student). 8-puzzle game is one of the intelligent games that can be used to assess psychological factors such as IQ levels, patience, perseverance, learning ability, etc. The playing of game is as follows:

1) 8-puzzle game is played by both human and system.
2) A 3*3 matrix is internally maintained by the system
3) The game consists of an initial state and a goal state.
4) Initial and goal states are generated by the system.
5) The player has to move one tile at a time so that the goal state is achieved at the end.
6) The number of steps taken by player to reach the goal state is compared with the number of steps taken by computer to reach the goal state and the score is computed accordingly.

1.3. Why to assess psychological factors

Career assessment is one of the most important tasks in student's academic life. Based on the career recommended by expert system

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a student is able to select an appropriate subjects and electives in his/her future studies to choose the best career path in student's life. Career assessment is mainly important for final year student's to find what jobs for which they are suitable in software industry. Hence, it is very important for expert system to assess the psychological factors of a student such as intelligence, patience and perseverance levels, etc.

1.4. Cognitive model

Cognitive model means a model related to mental processes like perception, memory, reasoning, intelligence, problem solving ability, judgement, etc. It contains approximate values of the levels of human intelligence, memory power, problem solving ability, learning ability, patience, perseverance, etc. The levels are expressed both qualitatively and quantitatively.

1.5. Expert system

It is a system based on Artificial Intelligence and it simulates the behavior of a human expert. It has a knowledge base, a database, an inference engine and an interface.

2. Literature survey

It is very important to choose the proper career(s) for a student. Normally, counselors (human experts) select the appropriate career(s) for a student basing on his/her academic record. To err is human. That means while selecting the appropriate career, even a human expert may commit error at times. Using AI Techniques an expert system can be built to replace a human expert. That system can be used to decide which career(s) are most suitable for a student. Apart from the academic track record of a student, various psychological factors like Intelligence, Speed of solving problem, etc. of the student should be considered by the system to make a better decision regarding the selection of suitable career(s) for the student. Game Playing is one such technique by which students psychological factors can be assessed. The following provides a survey of literature in this direction.

2.1. Expert system

Expert system (ES) uses human knowledge stored inside a computer to solve problems those require human expertise for solving. ES is used in many sectors viz medical, agriculture, mining, education, industry etc.

Abdullah Al-Ghamdi et al. [1] proposed and developed an expert system for advising postgraduate students instead of the traditional way in advising by the department's advisors. This system aims to assist postgraduate students of Computer Science (CS) major in King Abdulaziz University (KAU) to select the suitable courses during their postgraduate program. The proposed system enables the students to select and get a plan to each semester without needing to consult advisors.

Waghmode M. L et al. [2] has thrown light on literature review of career selection expert systems. For career selection the researchers reviewed 43 literatures including 2-conference proceeding, 8-Books, 22 Journals, 1-Report, 5-Thesis, 3-Websites, 2-Encyclopaedia articles and 2-generic articles. Articles referred are from last two decades and majority of them are latest.

S. Saraswathi et al. [3] focused on the construction of an online Expert System which guides the students for the selection of their undergraduate courses after the completion of higher secondary school education. The system will have the knowledge-base which contains the details about the colleges in Pondicherry. Rules are framed and an inference engine is developed which makes the Expert System. The constructed knowledge-base can be queried with domain related queries and the Expert System provides the most relevant details for the query.

M. L. Waghmode1 et al. [4] described the role of expert system in career selection. Researchers collected domain knowledge from domain experts, and designed a framework of expert system for career selection. Researchers used different machine learning classifier algorithms for classifying data into different career streams using Weka tool. The performance of these classifiers is described in this paper.

2.2. Cognitive model

Chandra Prakash et al. [5] made an analytical study and found that Sudoku is the best game to assess psychological factors of a student, especially decision- making power of a student. The authors proposed an Expert system that conducts Sudoku game for a student, assesses various psychological factors, builds a cognitive model of the student and provides career assessment.

Chandra Prakash et al. [6] present a critical study on applicability of Sokoban game for assessing student's psychological factors so that an Expert system can build a cognitive model of a student for career assessment.

Chandra Prakash et al., [7] designed and developed an expert system called Tic-Tac-Toe Game Playing Career Guidance System (TTT-GP-CGS) that is useful to assess the psychological factors of the student through Tic-Tac-Toe Game Playing, build the cognitive model of the student and predict the appropriate career(s) for the student.

2.3. Career assessment & guidance

Chathra Hendahewa et al. [8] developed Career Advisory Expert System, named iAdvice to guide students engaged in their higher education to determine their career paths and to select their course subjects to be in line with their career goals. Expert System features such as reasoning ability, providing explanations providing alternative solutions, providing uncertainty and probability measures, questioning ability are found in iAdvice. Abisoye Opeyemi et al. [9] designed and developed an Online Career Guidance Information System targeting students in pre tertiary institutions in Nigeria. The Online Web Based Career Guidance system was designed and implemented using data collected from interviewing human counsellors and surveys.

Chandra Sekhar [10] designed and developed an Expert System to assess Memory Power of a Student for Selection of a Suitable Career. Iryna Gurevych et al. [11] presented a study aimed at investigating the use of semantic information in a novel NLP application, Electronic Career Guidance (ECG), in German.

Ankie Bngtsson [12] argues that policy of career guidance aims to shape not only a competitive workforce, but in addition entrepreneurial and responsible citizens. The author discusses what desirable subjectivities government of career self-management constructs in relation to re-regulated responsibility of the individual and the state. Peter plant [13] discussed various issues and methods in related to Quality in Career Guidance.

2.4. 8-puzzle

Alexander Reinefeld [14], investigated 8-puzzle problem and his results include data on the expected solution lengths, the 'easiest' and 'worst' configurations, and the density and distribution of solution nodes in the search tree.

Daniel R. Kunkle [15], applied the A* algorithm which guarantees that the best solution (that with the least number of moves) will be found. Heuristics are examined to allow the algorithm to find the optimal solution while examining as few states as possible (maximizing the informedness of the heuristic).

Kevin Igwe et al. [16], proposed a machine learning technique, namely genetic programming, as means of solving the 8-puzzle problem. The genetic programming algorithm uses the grow method to create an initial population which is iteratively refined using tournament selection to choose parents which the reproduction, mutation and crossover operators are applied to, thereby

producing successive generations. The edit operator has been used to reduce the size of solution trees and hence the number of moves to solve a problem instance.

Masuma Sultana et al. [17]: Xyz provide a Complete Solution of Eight Puzzle Problem using BFS in Compute Unified Device Architecture (CUDA) Environment Objective of their work is to find the complete solution of eight puzzle problem i.e. examining all the permutations for solvability. Using Breadth First search (BFS) graph traversal we can reach the solution for a definite goal. The parallel algorithm is capable of providing us with much more faster solution using CUDA, HuaShi [18]: conducted a thorough analysis of the search solution for the Eight-puzzle Problem. The Breadth-first search algorithm, the Depth-first search algorithm, and A *algorithm are used to solve the problem. After this Survey we got the idea that we can develop an expert system that plays 8-puzzle game with a student and assesses the psychological factors of the student like Intelligence etc. Basing on the scores the system can predict the most suitable career(s) for the student.

3. Design of 8-puzzle game

We have to consider the academic record along with the cognitive model of a student in order to assess the suitable career for a student. We should assess various psychological factors (eg. intelligence, speed of problem solving, patience & perseverance, learning ability, etc.) We have developed 8 puzzle game and used it to assess the psychological factors of a student, and build the cognitive model of the student. Basing on the cognitive model, our Expert system can predict the appropriate career(s) for the student.

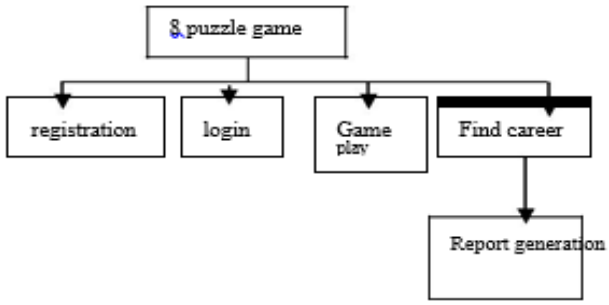


Fig. 1: System Architecture of 8 Puzzle Game.

The System is divided into different modules as shown in Figure 1.

3.1. Registration

Before playing 8 puzzle game, every student has to undergo the processes of registration. In the registration process, the student has to provide his/her register number, name, phone number, etc.

3.2. Login

The student has to login with username and correct password. This module is for security.

3.3. Game playing

Once the login process is completed, the student is allowed to interact with the system. The initial and goal states of the 8 puzzle game are generated by the system and are displayed to the student. The student can move one tile at a time. Thus, the student has to start at initial state, move to different intermediate states and finally reach the goal state. The score will be awarded basing on the number of moves played by the student.

3.4. Assessing psychological factors

Psychological factors are related to human intelligence, speed of problem solving, patience and perseverance, etc. of the student. These factors reflect the mindset of the student and define the person's thinking abilities, decision making and also have major influence in his day to day life.

a) Assessing Intelligence and planning ability

The word "Intelligence" means "the ability to apply the knowledge and skill to solve the problem". In order to get high score in 8-puzzle game, high level of intelligence is required to solve the puzzle in minimum amount of time. Generally, a student with high academic record will secure high score as he/she is very intelligent. A student with low academic record may secure low score. But, there is another possibility that the student with average or low academic record may secure high score in solving 8-puzzle game. This means that he/she has high intelligence levels. That student may get good score in academics in future if the student pays good attention in studies. Table 1 shows scoring in planning ability.

Table 1: Scoring in Planning Ability

S. No.	Score in Planning ability and intelligence (Quantitative)	Score in Planning ability and Intelligence (Qualitative)
1.	>= 9	Very high
2.	> = 7 & < 9	High
3.	> = 5 & < 7	Moderate
4.	< 5	Low

b) Assessing Speed of solving problem

The time taken by the student for playing each game is noted. The average time of play is computed in quantitative terms. This reflects the student's speed of solving problem. This can be converted in qualitative terms using table 2.

Table 2: Speed of Solving Problem -Quantitative to Qualitative Conversion Table

S. No.	Speed Of solving	Qualitative
1.	< = 30 min/game	Fast
2.	> =30min&<40min	Moderate
3.	>=40min&<50min >=50min	Slow
4.		Very Slow

c) Assessing Patience & Perseverance

For achieving reasonable learning ability. Student has to play minimum [6] games for assessing learning ability of student. If the number is less than [6] learning ability cannot be assessed. Learning ability can be calculated as per the following table 3.

Table 3: Calculating learning ability

	Learning ability	
S. No.	score(Quantitative)	Qualitative
1.	>=6	High
2.	>=3 & <=5	Moderate
3.	<3	Low

3.5. Finding suitable careers

The number of games played by the student is recorded. Depending on the number of games played by the student the score of patience and perseverance is computed as shown in table 4.

Table 4: Number of Games Played

S. No.	Number of games played (Quantitative)	Qualitative
1.	>=10	Very high
2.	>= 6 &<10	High
3.	>=3 &<6	Moderate
4.	< 3	Low

d) Assessing Learning ability

Student is requested to play the game for a number days and number of games played is recorded. Now consider all those average scores. If they are in increasing order then it reflects that the student has adequate learning ability.

In general, a counselor considers the academic record of accomplishment (Cumulative grade point average- CGPA) of a student and predicts suitable career for the student. But, we propose that, apart from considering CGPA, various psychological factors of the student should also be considered while selecting the suitable career. The table 5.1 given below shows various career(s) that are available in software industry. The expert system assesses the levels of psychological factors of a student belonging to computer science and engineering discipline and predicts suitable career(s).

4. Result analysis

A set of students belonging to final year B. Tech (Computer science and engineering) students played 8- puzzle game and the scores of the students are noted by the system. The system predicted the suitable career(s) for the students. Table 5 shows the results based on the assessed psychological factors that match to the career(s). The student's registered number, CGPA, psychological factors and the highest career for which he/she is suitable are shown in the Table 6.

We can observe, in general, that if a student exhibits good intelligence, he/she also gets good marks and maintains a good academic record. Generally, we can expect that if a student has high academic track record(CGPA) then he possesses a very high level of intelligence. Similarly, if a student has low CGPA, we can similarly expect that he possesses low level of intelligence. Of course, it is also possible, in rare cases that a student may possesses high intelligence but maintains low academic track record. One of the reasons for this anomaly may be that the student does not study well. Table 6 shows student's Intelligence score and CGPA. A graph (figure 2) is plotted by taking Intelligence score on x-axis and the student's CGPA on y-axis.

Table 5: Intelligence Score and CGPA

S. No.	Register no.	Intelligence (score obtained)	CGPA
1.	14003463	0.13	4.2
2.	14003567	0.25	5.2
3.	14003150	0.4	5.5
4.	14003566	0.25	6
5.	14003368	0.35	6.9
6.	14003200	0.35	7.14
7.	14003301	0.4	7.3
8.	14003104	0.35	7.7
9.	14003082	0.4	8
10.	14003161	0.45	8.4
11.	14003111	0.45	8.5
12.	14007237	0.5	8.5
13.	14003025	0.5	9

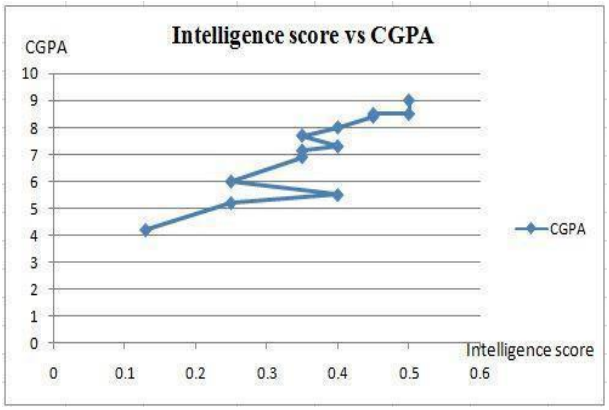


Fig. 2: Intelligence Score and CGPA.

In the above graph, it is observed that a student, who has high intelligence, has low CGPA. The reason behind this may be that either the student is not having good memory power or lack of interest in that particular course. By removing the data about such odd students, the graph became linear to some extent (figure 3). A correlation is established between CGPA and Intelligence score. That is, the students who secured good score in 8-puzzle game (the score reflects the intelligence of the student) have good CGPA. This is the proof that the game is rightly assessing the psychological factor i.e., intelligence.

Table 6: Intelligence Score and CGPA –Revised

S. No.	Register no.	Intelligence	CGPA
1.	14003463	0.13	4.2
2.	14003567	0.25	5.2
3.	14003566	0.25	6
4.	14003368	0.35	6.9
5.	14003200	0.35	7.14
6.	14003301	0.4	7.3
7.	14003082	0.4	8
8.	14003161	0.45	8.4
9.	14003111	0.45	8.5
10.	14007237	0.5	8.5
11.	14003025	0.5	9

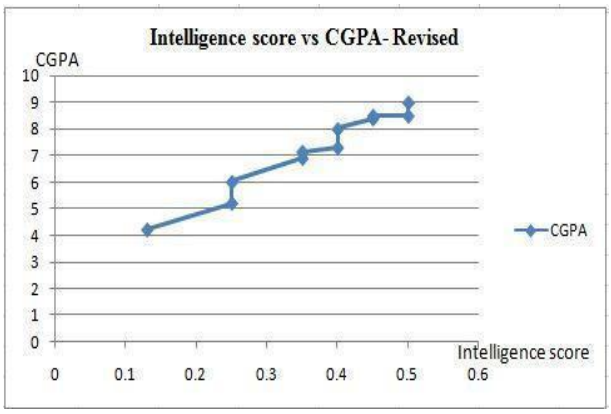


Fig. 3: Revised Intelligence vs CGPA

5. Conclusions

Apart from the academic record of a student, the psychological factors of the student also play a major role while predicting the best career(s) for a student. Though there are many traditional tests like Aptitude and reasoning tests, IQ tests etc. that are used to assess the psychological factors of a student, a novel idea is to assess the psychological factors through game playing because playing game is much more interesting for every student instead of attending other general tests. An expert system is developed that supports 8 puzzle game. The student plays the game several times and the expert system evaluates his performance, assesses the psychological factors, builds the cognitive model of the student and predicts the most suitable careers for the student. A correlation between intelligence score and the student's academic track record is established and this shows that the system is rightly assessing the psychological factors of the student. We have considered important job positions in software career/M.B.A/Civil Engineering so that the system could predict appropriate career(s) for the students. The number of career(s) can be extended so that the system will be useful for any graduate or a post-graduate student belongs to various disciplines.

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