International Journal of Engineering & Technology, 7 (1.1) (2018) 260-264

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

A critical study on applicability of sokoban game for building cognitive model of a student for career assessment

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Abstract

Career assessment is extremely important for a student to choose the best career in his/her life. A career counsellor may assess a student by considering his/her academic record and the scores obtained in IQ tests, reasoning, quantitative-aptitude, etc. and suggest a suitable career. After studies, when the student gets employment in his/her selected career, at times, the student may find it very difficult to continue in his/her career. A major reason may be that the psychology of the student may not match with the psychology that is expected for the chosen career. Hence, it is highly essential for the counsellors to assess the psychological factors of a student before suggesting a suitable career. Game playing is one method through which psychological factors of a student can be assessed. This paper presents 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.

Keywords: *Sokoban Game; Sokoban Puzzle; Career Assessmen; Cognitive Model; Expert System; Psychological Factors.*

1. Introduction

Companies are recruiting the candidate basing on the performance in IQ tests, reasoning, quantitative-aptitude, written exams, interviews, etc. After joining a company, a candidate may not be able to do well in his/her job as the psychology of the candidate may not match with the psychology that is expected for the job. For example, a computer graduate with good academic record and high IQ may join a software company as a tester. But as per his/her psychology, the candidate may be very impatient to do testing continuously. In that case he/she cannot lead a successful career as a tester. Let us consider another most important psychological factor viz. planning ability. If a manager does not possess a reasonable level of planning ability, he/she is not fit for a manager. Hence, it is extremely important for a counsellor to assess the psychological factors of a student before proceeding to career assessment.

There are many ways that can be adapted to assess the psychological factors of a student viz. planning ability, intelligence, logical thinking, decision making, speed of problem solving, patience and perseverance, etc. One way of assessing psychological factors of a student is through Game playing. There are many intelligent games in the world using which the intelligence of a student can be assessed. The authors of this research work are in search of a suitable game for assessing the psychological factors especially planning ability. The authors made a critical study on the applicability of Sokoban game for building a cognitive model of a student for career assessment. The research findings are presented in this paper.

a) Sokoban game

Sokoban puzzle was developed in 1981 by Hiroyuki Imambayashi, but released in December 1982. The word Sokoban in Japanese language means "warehouse keeper". Sokoban game is a type of transport puzzle, in which the player (Sokoban) pushes boxes or containers around in a warehouse, trying to move them to storage locations [1]. The puzzle is generally implemented as a video game.

Rules to play:

Sokoban game is played on a board of squares, where each square is board or a wall. Some floor squares contain one or more boxes and some floor squares contain their storage locations. The number of boxes is equal to the number of storage locations. The player can move horizontally or vertically onto the empty squares, but the player is confined to the board. A box cannot be pulled into another box or wall. A player can only push the box but he cannot pull the box. The game ends when the player is able to move all boxes to storage locations.

The problem of solving a Sokoban puzzle is proven to be NP-Hard, Sokoban game playing is also a very interesting problem for researchers in AI because it requires automated planning that needs to be done by a robot (player). Sokoban game is comparable to chess game due to its branching factor and its enormous search tree.

The following is an example of Sokoban game.

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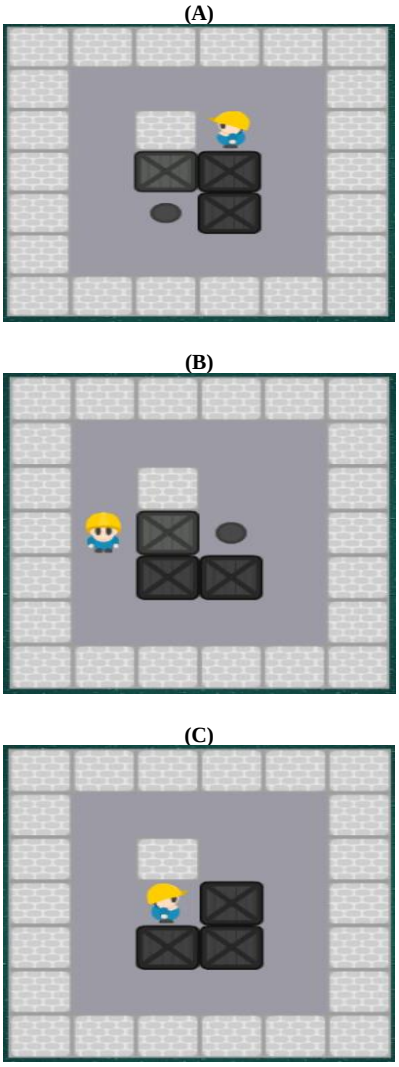


Fig. 1: (A) Initial State. (B) Intermediate State. (C) Goal State.

b) Career Assessment

Career assessment is useful for students and employees to choose better careers based on the scores obtained in career tests. Generally, teachers (counsellors) guide their students to choose suitable careers based on the academic track record, aptitude, reasoning and interests etc. Career assessment in the form of tests can be useful for those who are uncertain about their career. However, the present career assessments may not consider some of the psychological factors like intelligence, logical thinking, planning ability, patience & perseverance, learning ability, decision-making ability, speed of problem-solving, etc.

c) Cognitive Model

The word "Cognitive" means "relating to the mental process involved in knowing, learning, and understanding things". A cognitive model is an approximation of human/animal cognitive processes for the purposes of comprehension and prediction. The cognitive model of a student is the quantitative assessment of his/her psychological factors which include logical thinking, intelligence, speed of problem solving, patience & perseverance, planning ability and learning ability, etc. If a cognitive model of a student is built, the suitable career(s) can be predicted basing on that model.

d) Expert System

The word "Expert system" means "computer software that attempts to mimic the reasoning of a human expert". V. Chandra Prakash, J. K. R. Sastry et al. [2] designed an Expert system that plays Tic-Tac-Toe game with a student and assesses the psychological factors of the student, builds a cognitive model and predicts the suitable careers for a student. Haider Khalaf et al. [3] surveyed on the use of Expert system in the areas of agriculture, medical, automobiles and education.

2. Related work

a) Sokoban game

Demaret Jean-Noël et al. [4] presented their research article on hierarchical planning and learning to solve the Sokoban problems. They considered two important principles in human behavior while playing a game. The first principle is to decompose a complex problem into a sequence of simpler sub problems. The second principle is not to repeat the earlier mistakes. Basing on these two principles they proposed a new method for solving Sokoban game. Neng-fa Zhou et al. [5] presented a program written in B-Prolog to solve Sokoban problem. Their program is based on dynamic programming and it treats Sokoban as a generalized shortest path problem. Anthony et al. [6] presented their research article on general self-motivation and strategy identification. They illustrated their concept by taking two case studies based on Sokoban and Pac-Man games. Leme et al. [7] proposed a Domain-Dependent Move Pruning (DDMP) method to solve the Sokoban game optimally. DDMP is used reduce the number of explored nodes and total time. Ashlock et al. [8] proposed evolutionary algorithms for automatic assessment of the difficulty of Sokoban boards. Jarusek et al. [9] proposed two approaches for difficulty rating of Sokoban puzzle viz. problem decomposition metric and the computational model which simulates human traversal of a state space. Luzhnica et al. [10] presented the technical concept and technology choices of a virtual reality of the Sokoban game with a tangible version.

b) Career Assessment

Shi et al. [11] described the design concepts of game-based career guidance systems. They explained how digital games improve people's motivation and interest for career guidance. Ian Dunwell et al. [12] presented a new approach for career guidance. They introduced a serious digital game termed "Me-Tycoon" using which career guidance offered to students. Keishing et al. [13] presented a review on knowledge management based career Exploration System in Engineering Education. Aryani et al. [14] developed an application of career assessment model that provides career assessment for students of senior high school to select their appropriate department.

c) Expert System

V. Chandra Prakash et al. [2] developed an Expert system (ES) that plays Tic-Tac-Toe game with a student and thereby assesses the psychological factors of the student viz. intelligence, learning ability, patience and perseverance, speed of problem solving and builds the cognitive model of the student. The ES also provides career assessment for the students. Papadourakis et al. [15] developed an expert system termed "ARISTON" for career counselling. The ES uses psychometric questionnaires (feedback form) to assess the personalities, intentions, preferences for specific work environments. Bouaiachi et al. [16] proposed a prototype of an academic advisory Expert system for the new students for their major and the institutions selection. V. Chandra Prakash et al. [17] developed an Expert system that assesses the memory power of a student by conducting some tests. There are five types of tests viz. identification of technical words, person names and items in a picture, classes and objects and recognition of faces. Basing on the scores obtained by the student, the ES provides career assessment. Haider Khalaf et al. [3] surveyed on the different ways of using the Expert system in the areas of agriculture, medical, automobiles and education.

3. Applicability of sokoban game for assessing the psychological factors of a student

3.1. Why sokoban game?

The reason for selecting Sokoban game for assessing the psychological factors of a student, especially planning ability, is as follows: Sokoban is very intelligent game and is very popular. Many students play this game using their mobile phones. In order to

solve this game, a student should possess high level of planning ability, intelligence, problem-solving ability, learning ability, etc.
Demaret Jean-Noel et al. [4] stated that the planning phase involved in solving the Sokoban game is used to determine the order in which the goal state can be reached. They developed a new method based on planning to solve Sokoban game. Botea et al. [18] stated that heuristic search is very useful for playing games like chess and Chinese-checkers. They opined that heuristic search is of limited value for playing games like Sokoban, Go and Shogi. They proposed a framework that uses planning for solving Sokoban game.
Basing on the above research investigations, the authors feel that Sokoban game is the right choice to assess the planning ability and other psychological factors of a student.

3.2. Psychological factors

The psychological factors are mental factors that can support or avert people from being in the right path or way. These factors include aptitude, intelligence, planning ability, interest, problem solving ability, speed of problem solving, memory power, patience and perseverance, etc. These are the most important factors that can influence a person's occupational choice.

3.2.1. Problem solving ability

When we consider the Sokoban puzzle, we have different difficulty ratings such as easy, medium and hard. Each level has its own complexity. The game ends in three states a) solved b) unsolvable (the box or container is stuck up) c) incomplete. So, the player should be very careful in the movement of the boxes in order to avoid container "stuck up" state. The problem can be solved only when the player has a clear understanding of the problem domain and its rules. The player should also have a good planning ability before he/she starts the game. This ability is required in order to find the optimal path and obtain good score. Sung Ae Yoo, R Zellner [19] proposed three problem-solving strategies to solve the Sokoban game. They are trial and error method, means-end analysis and reasoning by analogy.

3.2.1.1. Logical thinking

Logical thinking means "thinking that is coherent (consistent) and logical". Logical thinking is required for Sokoban (warehouse keeper) for selection of the right (optimal) path and move the boxes to reach the goal states. The problem decomposition is also important to solve the problem. The level of logical thinking of a player can be assessed by considering the average score obtained by the player when he/she plays Sokoban game several times. Now a days, recruiters are conducting one or a few Sokoban games for a candidate who came for employment. They are trying to assess the logical thinking, intelligence and other psychological factors of the candidate basing on the scores and time taken for game playing.

3.2.1.2. Intelligence

The word intelligence means capacity for learning, reasoning, understanding, and similar forms of mental activity, aptitude in grasping truths, relationships, facts, meanings, etc.

3.2.1.3. Decision making

The literal meaning of the phrase "decision making" is as follows: It is the thought process of selecting a logical choice from the available options.
Ian Dunwell et al. [12] stated that understanding the relationship between immediate decisions and long-term career prospects is a vital skill in a job market. In Sokoban game, the decision making plays most vital role. Belmont et al. [20] presented a strategy of sequence of actions to push the boxes by mobile robot.

3.2.1.4. Speed of problem solving

The speed of problem solving is also a very important factor. When a student solves a problem with high speed, we consider him as very intelligent. V. Chandra Prakash, J.K.R Sastry et al. [2] proposed an Expert system that plays tic-tac-toe game with a student. The time taken by the student to solve the problem reflects his/her speed of problem solving. The Sokoban game is also a very intelligent game like tic-tac-toe and it can be used to assess speed of problem solving of a student.

3.2.1.5. Planning ability

Planning is the process of thinking about and organizing the activities required to achieve a desired goal. Planning is a fundamental property of intelligent behaviour.
Patrick Montana and Bruce Charnov [21] proposed a three-step result-oriented process for planning:

a) Choosing an endpoint (destination)
b) Evaluating the alternate routes and
c) Deciding the specific sequence of your plan.

In chess game, high level of planning is required before making the next step. Sokoban game also requires high level of planning in order to move the boxes or containers to storage locations in optimal path.
Demaret Jean-Noel et al. [4] presented their research article on hierarchical planning and learning to solve the Sokoban problems automatically. They proposed a new solving method which relies on two principles observable in human in-game behavior: the decomposition of a complex problem into a sequence of simpler sub problems and the non-repetition of encountered mistakes. Miyazaki et al. [22] designed a Hopfield networks that can coordinately attain the robot planning. The planning is a distinctive intellectual activity of a logical task. The planning is considered difficult for neural networks to do. We understand that Sokoban is one of the best games that can be used to assess the planning ability of a student.

3.2.2. Patience & perseverance

According to the Oxford English Dictionary, patience can be understood as the ability to accept delay or trouble calmly. It highlights tolerance. Being patient is when the individual is tolerant and endures pain, suffering, misfortune and other difficult situations. Most of us believe that it is those who are patient that reap the best benefits.
Perseverance refers to continuing in spite of difficulty and lack of success. This highlights that even in the face of repeated failure the individual still continues in his course of action. A perseverant individual is determined to achieve his goals in spite of all the difficulties that he encounters on his journey to success.
Chandra Prakash. V, J.K.R Sastry et al. [2] stated that the number of attempts made by a student in order to solve a game indicates the level of patience and perseverance of the student.

3.2.3. Learning ability

The word learning means "the acquisition of knowledge or skills through study, experience, or being taught". In Sokoban game, a student requires proper planning to find the optimal path. Day by day, if the student gets more score while playing Sokoban game, we can consider that the student possesses good learning ability. This ability is to be assessed quantitatively depending upon the progress of the student in playing Sokoban game. Chandra Prakash .V, J.K.R Sastry et al. [2] stated that if a student's score improves day-by-day while playing Tic-Tac-Toe game, then he/she possesses good learning ability.

4. Sokoban game vs. Sudoku game: a comparative study

Sudoku is an extremely popular game. A short description of the game is given by Lynce et al. [23]. A Sudoku puzzle is represented by a 9×9 grid, which comprises nine 3×3 sub-grids. Some of the entries in the grid are filled with numbers from 1 to 9, whereas other entries are left blank. It is solved by assigning numbers from 1 to 9 to the blank entries such that every row, every column, and every 3×3 sub-grid contains each of the nine possible numbers. Many researchers have shown great interest in generating-solving Sudoku game. There are more than 1500 research articles on this game. There are more than 100 IEEE papers on this game. A comparative study between Sudoku game and Sokoban game is presented below:

4.1. Problem solving

- Solving Sudoku game requires intelligence, logical thinking, decision making, etc. in order to reach goal.
- Solving Sokoban game requires planning, intelligence, logical thinking, decision making, etc. in order to find the optimal path.

4.2. Patience & perseverance

In solving both games, the player needs a lot of patience and perseverance.

4.3. Learning ability

In solving both games, if the player has patience and perseverance and also there is considerable improvement in the score obtained, then the player possesses good learning ability.

5. Discussion & proposal for an expert system

In order to assess the career of a student, a career counsellor considers the scores obtained in academics, reasoning, quantitative-aptitude tests, IQ tests etc. Similar tests are conducted for candidates for jobs in banks, public/private sector companies etc. But it is also important to assess various other psychological factors of a candidate. For example a bank manager should have patience to listen to the customer, explain the rules and regulations and should not lose his temper at critical times. He/she should have high level of perseverance to increase fixed deposit accounts. A software engineer in computer industry should have high level of learning ability to learn a new technology as and when it is introduced in the industry. He/she should be a life time learner.

The authors proposed an Expert system (ES) that can assess the psychological factors of a student quantitatively through Sokoban game playing and build a cognitive model. A cognitive model is simply a collection of levels of various psychological factors of a student that are measured through Sokoban game playing. In order to assess the psychological factors of the student, the following steps are to be followed i.e., the student registration, login to the system, Sokoban game playing, displaying the score and predicting suitable career (s).

During registration process of a student, the name, roll no, academic record and password are obtained from student and stored in a database. The student can login to system if the password is valid. The student has to opt for the level of the game viz. easy, medium and hard. A Sokoban game generator will be used to generate a game depending on the opted level of difficulty. When the student solves the game, the number of steps taken by him/her is stored in the database. The start and end times of the game are also recorded. Internally the ES will make use of Sokoban game solver to obtain the solution for the current game in minimum number of steps. The score for the current game may be computed by considering the ratio of number of steps played by computer (solver) and number of steps played by student. The student has to play the game a number of times and the average score is computed. A higher level of score clearly indicates the planning and problem-solving ability of the student. The ES considers the career table which was supplied earlier by a domain expert. This table contains each job and the required levels of psychological factors (qualitatively). The ES can map the quantitative score of each psychological factor of the student into qualitative words and carries out a matching process and displays the most appropriate career(s) suitable to the candidates.

6. Conclusion

The authors have presented a critical study on the applicability of Sokoban game for building a cognitive model of a student for career assessment. A comparison between Sudoku and Sokoban games are presented. The authors proposed an expert system that can assess the psychological factors of a student through Sokoban game playing. The ES can build a cognitive model of the student and predict suitable career (s) depending on the cognitive model.

Acknowledgement

This research work is part of the research project titled "Development of an expert system for career assessment based on cognitive model" funded by Department of Science and Technology – Cognitive Science Research Initiative scheme (CSRI) (Sanction order No SR/CSRI/129/2014(G)) of Government of India. The PI of the project is Dr. V. Chandra Prakash and Co-PI is Dr. J.K.R Sastry. The infrastructure for the project is provided by K L Education Foundation.

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