Tetris as a Task Environment for Research in Dynamic Decision Making, Attention, Categorization, and Cognitive Modeling

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Introduction

Tetris is a popular game that has been extensively studied in the mathematical and computer science communities (Hohenberger, Demaine, & Liben-Nowell, 2003). However, it is also a dynamic task environment in which a human decision maker must integrate perceptual information with game dynamics in order to determine where best to place a piece. Tetris makes for an intriguing experimental paradigm because it integrates attention, memory, learning, categorization, strategy selection, and decision-making in a single complex and interesting task. To explore this task environment, we analyze players' actions, eye-gazes, and saccades as a function of the falling piece, the contour of the board, and experience level. We also attempt to develop a user model of Tetris performance that considers similar aspects of the game and selects similar strategies to those of the human players (based on experience level). Current analyses are in the initial stages, and the range of research presented here is a mere fraction of what is afforded given this task environment.

Human Data

Eye-gaze, key-press, and piece placement data have been collected from Tetris players of various expertise levels. These three types of data can be analyzed separately and then combined to flush out the cognitive mechanisms involved during game play.

An eye tracker was used to sample the position of the eye every 16ms while participants played the game. These samples were consequently combined into fixations whenever there were at least 6 samples falling on the same location on the screen.

Once the fixations were extracted, analyses could be done on the number and duration of eye fixations on the accumulation at the bottom of the board and the floating piece during each decision trial (piece fall). Gaze sequences could then be analyzed per piece type and with respect to experience level. In addition, eye data could be used to infer what information people look for when determining where to place the piece (i.e., scanning the piece or accumulation).

Preliminary analysis of 26 Ss revealed some interesting trends, with Ss saccading to 'easy' pieces (I and O) only once, and all other pieces about twice on the average during a single drop. Also, as skill level increased, the number of saccades to the piece per drop decreased, suggesting that more experienced players have a better internal representation of the piece and its possible orientations.

Key press data was also recorded during game play to determine the sequence and number of rotations and translations performed during each trial. Preliminary analyses show that on average players rotate the piece no more than the number of times required to see every orientation.

Board configurations were recorded and used to assign a location to each eye gaze, as well as for matching human to model data.

Cognitive Model

A basic user model was developed as a step towards the development of a cognitive model of human performance. The model used the following strategies: avoid making holes, clear lines when possible, keep the contour of the accumulation level, and reduce the number of vertical edges. In direct human-model comparisons, the model matched ≈57% of the decisions of the best Tetris player, and ≈20% of the worst (chance ≈5%). Future work will involve tuning the model's decision strategies based on human expertise level.

Summary

Although it has been shown that Tetris is a NP-complete task (Hohenberger, Demaine, & Liben-Nowell, 2003), and that every Tetris game will eventually end (Burgiel, 1997), people nevertheless enjoy this game and can become quite good at it. Thus, the goal of this research is not to solve the game of Tetris. Rather, it is to understand how humans allocate attention and make decisions during the game, and to develop high fidelity cognitive models of this type of decision-making.

References

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