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## Group Performance on Computer Games in Chess and Checkers

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To study on the group benefit and performance, this research started with sub-research question “What is the effect of group size when playing the game of Chess?”. The following research objective is formulated, investigation on Majority Voting is conducted in order to find the essential information. After that, next purpose is to accurate the experiment result, locate support evidence from other perspective and further investigate on stability issue. The principal aim is to find the relationship between group benefit and performance in Majority Voting, and factors which can further improve efficiency and stability. The suggested hypothesis is that ‘as stability increases the performance increases’. First, experiments were performed on groups of Chess programs to test the effect of group size on performance. Observation is mainly on homogeneous groups (copies of the same Chess program), as opposed to heterogeneous groups (different Chess programs). Groups were made up of Stockfish. Simple Majority Voting was used to mechanically combine the individual Chess program's decisions into a group decision. Games of Chess were played between groups of increasing size, and individual Stockfish was used as an opponent. Results show that winning rate increases as group size increases.

However, second question is that “Dose the effect of increasing in performance also apply to game other than Chess?”. This question is to confirm that performance in artificial intelligence other than chess can be improved by this method because just investigating on Chess, the result might be biased and insufficient. This time, the experiment subject will change to checkers due to concern of appropriateness in complexity of game level and for diversity in experiment result. The principal aim is to find and verify the relationship between performance and stability performed by Majority Voting, and factors which can further improve performance. To further investigate the possible potential, Checkers is an interesting subject. Chess is much above in complexity compare to Checkers, the experiment might results in variety due to situation. The experiment subject will move to Checkers for diversity in experiment result for further conclusion. For further investigate in Majority Voting, experiments on groups of Checkers programs, playing by majority voting, were performed to investigate performance and stability. Homogeneous groups, copies of the same program, was also used to perform these experiments instead of heterogeneous group that was more complicated by factors of different programs. Experiments were performed based on a search-depth of 5, 10 and 12 using the Samuel checkers program. Games of Checkers were played between groups of size ranging from 1 up to 10 for each side. Experimental results of majority voting in Checkers suggest that group performance increases as a kind of logarithm function as the group size gradually increases for stronger player, and the performance slowly decreases in the case of a weaker player. In addition, stability seems to increase as the group size increases. The result can be assumed that for higher n number of group size, the smaller in difference

of the average interval of winning ratio between each node, which means the decreasing of fluctuations and an eventual stabilization of the average value.

Lastly, the next question is “Can the performance enhanced methods work with each other?”. Another effective method that was universally used nowadays is Machine learning, for the past decade Machine Learning has become more influential in information technology and artificial intelligence. Experiments on groups of Checkers programs, playing by majority voting of reinforcement learning AIs, were performed to investigate performance and other relationships. Homogeneous groups, copies of the same program, were still used to perform these experiments. Experiments were performed and observed on variation of number of 500, 1,000 and 1,500 train games using reinforcement learning Checkers program. Games of Checkers were played between groups of size ranging from 3 up to 13 reinforcement learning Checkers program and a standalone traditional alpha-beta pruning Checkers program as a base performance comparison. The main purpose of this experiment is to verify that difference enhanced methods can work together and further improve each other. Results of the experiment still suggest that group performance increases in boundary of logarithm function as the group size increases for stronger players, and the performance slowly decreases in the case of a weaker player. Furthermore, we can presume that by increasing in train games and members in group makes the program more stable and also increasing in performance. However, the results of this study also indicate that as group size becomes larger, at one point the performance will stop increasing noticeably and sometime the performance swing between increasing and decreasing in kind of see-saw effect but overall, the performance satisfactorily increases.