Development of a Generalized Artificial Intelligence for Playing Perfect-Information Games.
(Technical topic)

The Influence of Social Interest Groups on Computing - A Case Study in the Development of Chess-Playing Artificial Intelligence.
(STS topic)

A Thesis Prospectus
in STS 4500
Presented to
The Faculty of the
School of Engineering and Applied Science
University of Virginia
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By

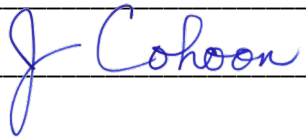
Tazz Stieglitz

April 23, 2013

On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed: _____ Date: _____

Approved: _____ Date: _____

Approved:  Date: _____

Introduction

Historically, the development of the field of artificial intelligence has been considered a relative measure of the development of technology as a whole. In turn, the progress of game- playing artificial intelligence has been seen as a general measure of the progress of artificial intelligence as a whole -- indeed, many problems that are not generally considered "games" could be represented in a form identical to that of a game.

Under the guidance of Professor Gabriel Robins (Computer Science), a three-semester project shall be conducted in attempt to research and develop a generalized algorithm for solving perfect-information games -- a distinct subset of games where every player is in possession of identical information throughout the course of the game. The project will be realized in the development of a well-documented program, complete with some form of API, that can solve simple arbitrary perfect-information games and play more complex perfect-information games heuristically. This will be accompanied by a 10-15 page engineering report detailing the development details of the program and the concepts behind its functioning.

Alongside this technical project, an STS paper will be written under the guidance of Professor Joanne Cohoon. This paper will examine the societal, political, and economic circumstances under which chess-playing AI has historically developed, paying special attention to the various interest groups involved in shaping its development. This project will be finalized with a 10-15 page report on the findings of this research.

Technical Project

The ultimate goal of the technical portion of this senior project is to create a computer program that adheres to the following specifications:

- Potential to optimally play any perfect-information game

- Ability to determine if a game is perfectly playable within given time constraints, and if not, switching to a (likely inadmissible) heuristic-based solution
- Some method of developing said heuristic from the rules of a game
- An API, allowing external programs to interface with the AI

The program will be made in C++ and built for Linux and Windows. The games will be specified in Game Description Language (Love & Geneserith, 2004) or a similar language.

Perfect-Information Game Solvability

A game is categorized as "perfect-information" if every player shares the same knowledge of the game state. More formally:

- All data is categorized as either "local" to a specific player, or "global"
- No player is given another player's local data
- Changes in the game state are independent of any player's local data
- All players are given access to the same portions of the global data
- All players are aware of all of the other players' potential moves

Changes in the game state occur only when any player makes a "move" -- a choice from a set of pre-defined functions to apply to the board. A player "solves" a game by choosing each move such that that player's chances of winning the game are highest, compared to if they had chosen any alternative move. "winning" the game consists of causing the game state to match a pre-defined win condition, representable as a function from game states to a Boolean value.

Tractability Analysis

The program will have a means of estimating the potential time to evaluate the state tree, or size of the state tree -- likely via state sampling or simply calculating the number of possible configurations of

the game state as raw data. If this value is found to be above some user-specified threshold, the program will cease attempts to play the game perfectly, and fall back to a generated heuristic solution.

Heuristic Development

If the program chooses to fall back to a heuristic solution, or if it is specified by the user to do so, the program must have some means of generating a heuristic from the rules of the game. A heuristic is considered acceptable if it tends to perform statistically better than completely random moves. In some cases, finding such a heuristic cannot be done in reasonable running time. In this case, the program will fall back to random move choice.

API

The exact implementation details of the API are yet to be established, but the functionality will include at least:

- A means of retrieving the program's selected move in a given situation
- A means of retrieving the current game state of a running program
- A means of providing the program with a move for a given player to execute
- A means of specifying a game to a running program
- A means of specifying program operation flags, such as whether to fall back to heuristics or not

It is worth noting that this API should be sufficient to build a decoupled graphical interface for the program.

Engineering Report and Documentation

The engineering report accompanying this project will be 10-15 pages. It will explain the flow of the program, detail various theoretical considerations made throughout the development of the program, and explain implementation choices made and the reasoning behind them. The report alone should

provide reasonably convincing evidence that the program does indeed meet specifications, and should provide adequate information to understand the general functionality of the program. Additionally, documentation (~5 pages) will be provided, detailing specifically how to operate the program and interface with the API.

Significance and Ethical Concerns

The ultimate goal of artificial intelligence has been said to simulate human thought or behavior. Games have been used as a test of intelligence historically, and the field of artificial intelligence has targeted games as a simplified form of human intelligence almost since its very beginning (Schaul, Togelius, & Schmidhuber, 2011). In the research and development of this AI, we hope that some new techniques for efficiently playing games may be uncovered. By extension, these techniques will likely be applicable to other fields in AI or computing in general. Furthermore, the software developed may be usable as a platform for further research or AI development. Commercial applications may also be possible.

As with all developments in artificial intelligence, there are a wide variety of ethical issues to concern. There are those who are concerned with the issue of technological singularity (Vinge, 1993), groups that feel artificial intelligence is unnatural and wrong, and people who feel disenfranchised by computers. The issue identified as most directly related to this topic, however, is that of the actual integration of game-playing AI into games, on a professional level.

STS Thesis

The STS portion of my thesis will attempt to identify critical interest groups that have helped to shape the development of chess-playing artificial intelligence over the course of history. My thesis is that various social groups -- including engineers as well as non-engineers -- have had significant impacts on the historical development of chess playing AI.

The argument supporting my thesis is divided into two parts. The first is an analysis of a large body of historical instances where the interests of various social groups have collided with the realm of chess. These instances will be analyzed under ANT in an attempt to explain the developments that occurred in the world of chess AI in response. The second part of the argument relies on the high degree to which the AI and computing communities as a whole have focused on chess AI development historically. In this part, I will perform an analysis of the body of reasoning among the AI and computing communizes as to the importance of chess AI in an attempt to determine the areas where they have strongly influenced its development. This division of interest groups is reasonable due to the fact that the AI and computing communities have exerted -- as one might expect -- a very large influence over the development of chess AI throughout its history.

The evidence used to support the first part of the argument will consist primarily of documents describing the interactions of various social groups with the world of chess AI. Examples include records of IBM's funding for the development of the "Deep Blue" chess playing computer (IBM, n.p.), regulatory documents by FIDE, the international regulatory body for chess (FIDE, 2012), or personal accounts of interaction with chess AI from individuals such as world chess champion Garry Kasparov (Kasparov, 2010). The second part of the argument will rely mostly on papers written by authoritative individuals in the fields of computing. One additional resource of note is an article by Nathan Ensmenger titled *Is chess the drosophila of artificial intelligence? A social history of an algorithm* (Ensmenger, 2001), as it is one of the few academic *sociological* inquisitions as to why such a strong focus on chess is present in the AI community.

The method used will primarily be an ANT analysis of the network of social interest groups surrounding the development of chess AI as it has changed over time. The group focused on in the second sub-argument is simply a disproportionately influential actor (and thus demands a disproportionately large portion of our focus) in this network, and will be analyzed in much the same way, but with more

focus placed on the specific actions of the group as an individual actor, rather than as a component of the network.

References

Ensmenger, N. (2011). *Is chess the drosophila of artificial intelligence? A social history of an algorithm.* Social Studies of Science , pp. 5-30.

IBM. (n.d.) Deep Blue. Retrieved from http://www03.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/

Kasparov, Garry. (Feb 11, 2010). The Chess Master and the Computer MIT Press.

Love, N. and Genesereth, M. (Dec. 6, 2004). General Game Playing: Game Description Language Specification.

Schaul, T., Togelius, J., & Schmidhuber, J. (2011, September). Measuring Intelligence through Games.

Vinge, Vernor. (1993). The Coming Technological Singularity: How to Survive in the Post-Human Era. Vision-21: Interdisciplinary Science and Engineering in the Era of Cyberspace, pp. 11-22.

World Chess Federation - FIDE. (2012). FIDE Anti-Doping Regulations. Retrieved from www.fide.com/fide/fide-anti-doping-regulations.html