

# Rolling Horizon Evolutionary Algorithm Improvements for General Video Game Programming in Single and Multi-Player Games

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## Abstract

Artificial Intelligence is a field concerned with creating an agent capable of rational thought. When applied to games, the agent must be able to make decisions which would lead to fulfilling its goal (usually winning, possibly against an opponent). General Video Game Playing (GVGP) is a sub-field which aims to design an agent which would achieve high-level play in any given game, thus raising the need to generalize the heuristics used and introduce various machine learning techniques to gather information about the previously unknown game. While Monte Carlo Tree Search (MCTS) has dominated GVGP, Rolling Horizon Evolutionary Algorithms (RHEA) have the potential to reach an even better performance. The proposed study will focus on improving RHEA, using mostly the GVG-AI framework for testing purposes. On successful completion, the research will have a great impact on the game industry, bringing forward better AI and new challenging experiences for players.

## I. INTRODUCTION

Although traditionally Tree Search is the technique of choice for action decision making games, Rolling Horizon Evolutionary Algorithms (RHEA) are also an option. Evolutionary Algorithms (EA) are usually trained off-line and used afterwards to play the game, however, RHEA approaches use a forward model to simulate playing the game and evolve plans of actions. RHEA has enjoyed success in deterministic games, such as the Mountain Car problem [1] or the Physical Travelling Salesman Problem [2]. However, the algorithm struggles in stochastic games [3].

A notable contribution which shows that Evolutionary Algorithms should outperform MCTS (if correctly configured, in the case of GVGP) was made by comparing a Truncated Hierarchical Optimistic Open Loop Planning (T-HOLOP) [4], with a version of an EA which uses a Covariance Matrix Adaptation Evolutionary Strategy (CMA-ES) [5], EVO-P. The results gathered in this paper [6] indicate that not only does EVO-P obtain better results, but T-HOLOP has difficulties in even finding a solution.

## II. RESEARCH PROPOSAL

The study I wish to carry out is meant to further explore the usage of RHEA in the field of General Video Game Playing (GVGP). A first attempt would be to improve the base algorithm's performance, by focusing on the fitness evaluation of each individual of the population. Because of the large size of the search

space, the same exact sequence of actions may only be obtained once and the correct evaluation of the sequence and sub-sequences makes a large difference in exploring the search space effectively.

Macro-actions could be obtained not only from self-play, but also replays, from both bots and human players. The algorithm will attempt to identify patterns in various replays – the ability to recognize a winning scenario, for example, would be a great advantage. One way to achieve this behaviour would be to use deep convolutional neural networks (DNN), which, as explored by Maddison et al. [7] and Silver and Huang [8], can beat the traditional search algorithm GnuGo and match the performance of MCTS programs in the board game of “Go”, one of the long-standing grand challenges of AI. Adapting the technique to GVGP could turn out to be a very interesting and rewarding task.

Furthermore, there are several modifications which should be exhaustively tested and optimized for GVGP. As noted by Perez et al. [9], combining EA and MCTS, by evolving the Monte Carlo simulation, is a step forward, which should be further examined and improved. Moreover, EA could also be combined with other RL algorithms, such as Temporal Difference Learning (TD) or Q-Learning.

Last but not least, a significant improvement would be to introduce a form of multi-objective optimization [10], which would play a role in better evaluating the fitness of each individual, as well as allowing the agent to explore different ways of winning – as this might mean getting the highest score, the least amount of time steps, staying alive for as long as possible or simply winning the game, no matter what. Therefore, the agent should be able to better analyse the game states and recognize what its goal should be, as well as being able to adapt and switch from one goal to another as the game progresses.

### **III. IMPACT**

The successful completion of this study would result in an agent capable of high-level play in any given game, possibly out-performing MCTS algorithms. Few games companies currently employ advanced AI in their games, but this could change with the possibility of a more flexible, adaptive and more easily understood AI. With evolution being brought to a competitive standard and maybe even combining the two approaches, a new technique will top the market and become the new controller of choice, ready to offer an even better experience to the players, taking a new step forward in the research for actually intelligent agents, able to evolve and adapt to various environments, previously unknown.

### **IV. INDUSTRY**

I have not made contact with any organisations yet. However, several game companies are already employing MCTS AI for better behaviour in their games, in order to give the players a more realistic experience and they could benefit from a more flexible and adaptive option which RHEA could offer. Creative Assembly were among the first to make use of this technique in their games, through “TOTAL WAR: ROME II” (2014). Their MCTS algorithm required several modifications in order to perform well in the given scenario, such as aggressive pruning, eliminating duplication and soft restrictions [11].

Another example is Lionhead, who use MCTS AI in a cooperative action role-playing game “Fable Legends” (2016), the last in the “Fable” series [12]; their aim was to create a strong tactical AI, capable of proactively planning new strategies and surprising the players, by providing new interesting challenges. This is one example where a successful RHEA algorithm would perform even better, as it would be better suited to create new exciting situations by evolving its plans to even adapt to each player’s individual style.

# Rolling Horizon Evolutionary Algorithms PhD Plan

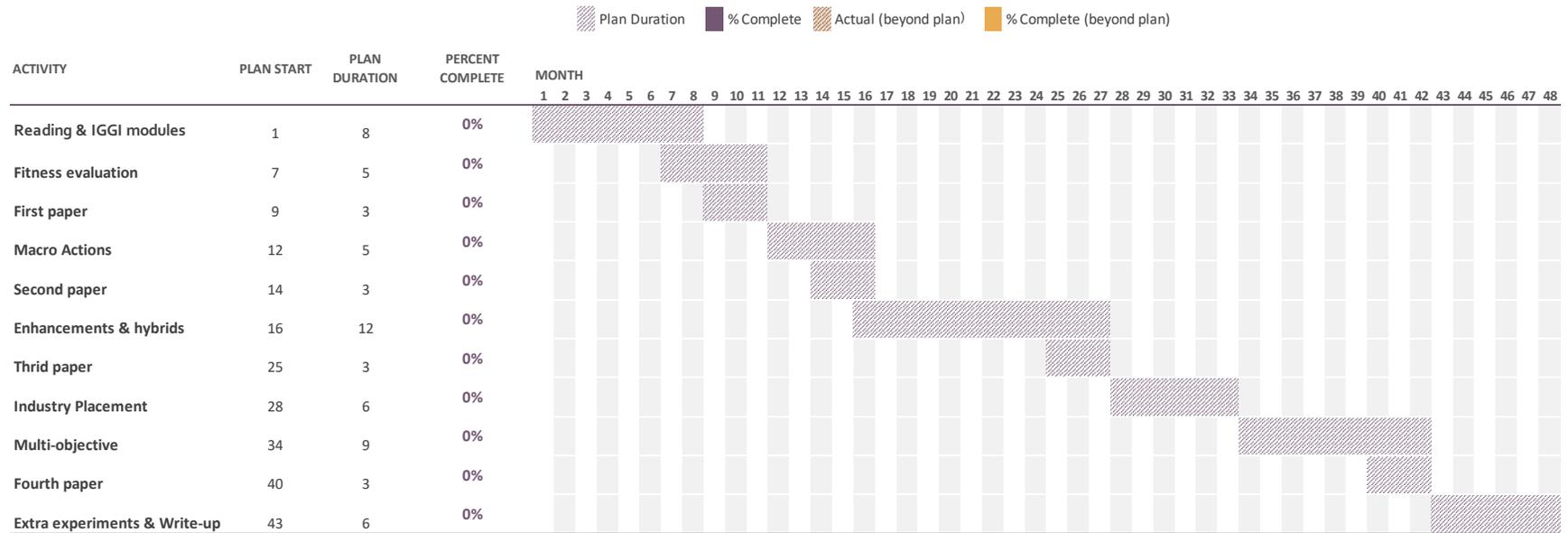


Figure 1 Gantt Chart summarizing PhD milestones, indicating plan duration in months.

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