An Evaluation of the Benefits of Look-Ahead in Pac-Man

Thomas Thompson, Lewis McMillan, John Levine and Alastair Andrew

Abstract— **The immensely popular video game Pac-Man has challenged players for nearly 30 years, with the very best human competitors striking a highly honed balance between the games two key factors; the 'chomping' of pills (or pac-dots) throughout the level whilst avoiding the ghosts that haunt the maze trying to capture the titular hero. We believe that in order to achieve this it is important for an agent to plan-ahead in creating paths in the maze while utilising a reactive control to escape the clutches of the ghosts. In this paper we evaluate the effectiveness of such a look-ahead against greedy and random behaviours. Results indicate that a competent agent, on par with novice human players can be constructed using a simple framework.**

I. Introduction

Pac-Man provides a point in history where video games moved into new territory; with players having their fill of the immensely popular space adventure genre with titles such as *Galaxian/Galaga*, *Asteroids* and the classic *Space Invaders*, Pac-Man brought players down to earth and more specifically trapped them in a maze. Historically this caused a shift in the focus of gaming developers, as the concept of maze-based video games became an overnight sensation, with many clones and bootlegs rapidly emerging in the market. Unbeknownst to many this style of game promoted not just a change in games that are played, but the thought processes required to play these games. The physical tools themselves had not changed, but the mental models required to process these tasks were dramatically different.

If we take *Space Invaders* as an example, we are presented the task of eliminating enemy ships whilst not succumbing to overwhelming numbers and firepower. The game required players to repeatedly mash the fire button whilst reactively moving away from any enemy fire, or towards enemies which were approaching the bottom of the screen. In comparison, Pac-Man presented little similarities, with the player focussing on overall strategy formulation; the difficult task on navigating throughout large mazes of varying shapes whilst avoiding the enemy ghosts provided something novel for it's time.

While Pac-Man may be considered trivial in comparison to modern day video games in terms of scope and control, the challenge provided is still relevant today to humans and machines. To this day contenders still attempt to reach and (unlikely) break the world Pac-Man record (3,333,360 points held by Billy Mitchell) meanwhile academics seek to try their hand in developing agents capable of playing the game. Several attempts in developing agents has focussed on the use of training algorithms to develop agents using machine learning practices [1], [2], [3], while this is a noble attempt we feel that such practices are best applied in small scope problems. While this could most certainly apply to ghost avoidance strategies, the ability to look ahead into the game world and begin to plan paths through the maze is often ignored. We consider the best means to attack the Pac-Man problem is to view at varying levels of reasoning; from high level strategy formulation to low level reactive control.

In our initial work in this domain, we sought to assess our hypothesis that the benefits of simple lookahead in Pac-man can be applied to generate a more competent agent than those using greedy or random decision processes. In this paper we give a recap of the Pac-Man domain and the particulars of our implementation in Section II and related work inSection III. The design for the agent architecture used in these experiments is provided inSection IV and the experiment breakdown and results are found inSection V. We discuss our findings in Section VI aswell as future directions for our research and give our concludingthoughts in Section VII

II. Pac-Man

Pac-Man is an arcade game developed by Namco and released in 1980 (under the original title *Puck-Man* in Japan) with subsequent localisation and redistribution in America by 1981. Pac-Man was one of the most influential video games of the 1980's by breaking away from the conventions of successful games such as *Asteroids* and *Space Invaders* and is to this day one of the most popular video games of all time [4].

The player is given charge of the titular character, with the task of consuming the 'pills' throughout the maze. To stop the player are four ghosts; commonly known as *Blinky* (red), *Inky* (cyan), *Pinky* (pink) and *Clyde* (orange). The ghosts are charged with hunting down the player, with contact between the Pac-Man and any ghost resulting in the loss of one of 3 lives. The only defence against the ghosts is the use of a 'power pill', which gives Pac-Man the temporary ability to consume the ghosts (encouraged by the significant bonus this adds to the players score). During this time the ghosts switch from aggressive to evasive in nature and avoid the Pac-Man as best as possible until the effects of the power pills consumption have faded. Only 4 power pills are provided in a given level, typically in the far corners. Furthermore, bonus items or 'fruits' appear in the centre of the level regularly throughout the game. These items also provide a large score bonus for the player.

There are a few changes that have been made in our own simulation of the Pac-Man game shown in Figure 1. While our version replicated the majority of the features of the original game, on both a functional and cosmetic level, we

Strathclyde Planning Group, University of Strathclyde, Glasgow, G1 1XH, UK, email: (forename.surname@cis.strath.ac.uk).

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