**“Mini-flex” Breakout Agent**

**Overview**

The primary goal of my project was to construct an agent that combines elements of reflex agents and minimax agents in the hopes of producing something that resembles human behavior when playing a game, and to compare the performance of this agent with its constituent agents in their pure forms. I chose Breakout because it was one of the only Atari games I actually understood the rules for, and because I thought it provided a straightforward basis for dissecting the algorithm. After days of testing my limits and doing my best to get a hang of the Open AI Atari environment, I decided my agent would react to the ball when it is moving downward towards the paddle, and as this is happening the agent will run a minimax algorithm to determine which direction to move the paddle and prevent loss of life. It wasn’t too much trouble coding a reflex agent, but coding a useful minimax agent proved to be impossible (for me anyway). I hoped that bridging the gap would solve the problem, but it did not. As a result, my objectives for the project changed a lot as it went on, and I ended up learning about different things than I initially sought to learn.

**What I Wanted to Learn**: Does combining the reactive element of reflex agency and the predictive element of minimax agency produce a human like agent? Does it produce a high-performance agent? How does the mini-flex agent compare to minimax and reflex agents? Does the minimax agent offer any utility in an environment that can clearly be dominated by a sufficiently sophisticated reflex agent?

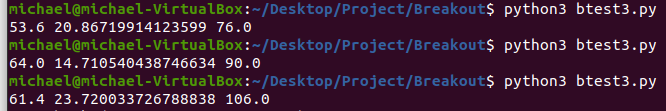
As we will see I didn’t end up answering most of these questions, but I answered some other higher resolution questions in the process.

**Methodology:**

Reflex Agent: The reflex agent is a fairly unsophisticated and generic one, but the results show that it performs better than I do, and since I was going for a comparison to human behavior and techniques, I am happy with its output. Here is a video of it reaching 99 points, a score pretty high above anything I have scored.

<https://www.youtube.com/watch?v=ODKCEj-cVPA>

Here are the results from 3 test runs of the current version of the agent.

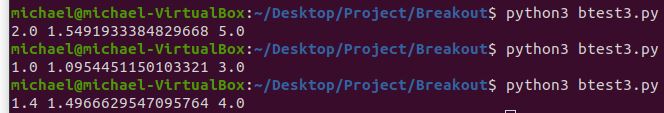
 Its average score was around a 50, which is better than I can do, and its high score was a 175, which I can’t even come close to. So I left it at that and planned on using it as a bench mark. But as they say, “man makes plans and God laughs…”

Minimax Agent: I did my best to model my minimax algorithm by my submission for the Pacman assignment. After proofreading it countless times and looking for errors, I began to realize that it simply runs too slowly to be of any use. Even when I limit the depth of the minimax tree to 2 levels, the game takes place at about 2 frames per second, and the construction of a tree is completely unnecessary if it only has 2 levels. On top of this, I repeatedly encountered an issue where the game would cease at an earlier point the greater the depth of the minimax tree. To solve this was a journey not for the faint of heart. The step method returns the value for is\_done(), which I believed was being returned as True too early. From here I opened atari\_env.py to find the step() method, which called game\_over() to retrieve the terminal status. So, I opened ale\_c\_wrapper.h, which referred to ale\_interface.cpp(), which contained game\_over(), which read simply as “environment->isTerminal()”. This took me to stella\_environment.cpp, where I tried forcibly increasing the value of m\_max\_num\_frames\_per\_episode to like a million. This appeared to do nothing, so I took it a step further and updated isTerminal(), which seemed to do nothing again. Finally, I overwrote isTerminal() with the line “return false” in an attempt to have each episode play until the game ended. This didn’t seem to work either, although I am still not sure why. Despite all that, I think that my problem was that I was trying to copy “env” by simply stating “tempEnv = env”, but because of the way Python handles pointers, tempEnv simply pointed to the same env, and every step I took in the minimax tree, it counted as a step in the original “env”. This is why I had to use the clone\_state() and restore\_state() functions in my minimax algorithm. Somehow, this fix allowed me to run games until they were complete, even though all evidence pointed to the problem having nothing to do with the step count. But after all of that I found that the clone and restore business made it even slower. The conclusion of this grueling process of discovery and personal growth is that no matter what I did, the minimax trees that were being generated by the agent could not be deep enough to even reach the point that the frame at which the ball reaches the bottom of the screen, or at which the ball collides with a brick. This means that all of the levels of the trees being generated were returning rewards of 0, nullifying the minimax algorithm entirely.

MiniFlex Agent:

I was hoping that thi

<https://youtu.be/QxUeO1dfCMY>



This video shows how slow miniflex is with a depth as low as 5:

<https://youtu.be/SclAURxnBio>

It is easily conceivable that a player would need to start moving 5 steps before the ball reaches the paddle, as the paddle may be on the wrong side of the game board and require 5 steps to make it under the ball.

**Outcome:** The results of this project ended up being far from what I had hoped. I would consider it a total failure if I hadn’t learned so much in the process.

**Some things I did learn:**

* Even with simple agents, wrappers and preprocessing are essential in the process of creating something useful. I can’t shake the feeling that had I applied greyscale and down-sampling correctly, my minimax algorithm could have at least worked efficiently enough for me to test it and correct my blunders. Unfortunately there was something I was seriously not understanding about how to apply the wrappers, and I Googled and Googled to no avail.
* No matter how complex I think it is, working with software packages like this can be even worse. This is the first time I have used any kind of software this complicated, and it took me by surprise. I worked on this project more-or-less as much as I possibly could, and the errors and hiccups I encountered every single step of the way were astounding. Every single shell command, every single new function call, and every single algorithm trial. All but a tiny handful, I encountered some kind of error that either required Googling or a deep-sea excursion into the sea of terror that is python\_packages/gym/. Just opening the ale\_en
* Programming any kind of agent on visual data alone is a nightmare. Wrappers would have helped, but the crux of the issue for me was having to scan through every pixel to know where each entity was, instead of having a kind of gridworld lay out that I am used to.

**Relevant Links**

OpenAI Gym: <https://github.com/openai/gym>

My Project: <https://github.com/>

Screen Recorder: <https://jp9000.github.io/OBS/features/subregion.html#:~:text=To%20easily%20select%20the%20select,to%20show%20on%20stream%20later.>

Integral Searches:

Why I didn’t do DQN: <https://becominghuman.ai/lets-build-an-atari-ai-part-1-dqn-df57e8ff3b26>

Nautilus: <https://askubuntu.com/questions/265641/how-to-open-a-folder-with-gui-from-terminal#:~:text=Use%20the%20command%20nautilus%20%3Cpath,run%20gksu%20nautilus%20.>