Abstract:

Super Smash Brothers Melee (SSBM) is a classic GameCube video game. Shortly after being released as a family game in 2001, SSBM developed a widespread competitive scene that is even more extensive today. A 2D platform fighter, the game offers exciting challenges to machine learning that have been unexplored by other projects, such as the Open AI Gym’s Atari project. Unlike many previously examined games like Pong, SSBM features a tremendous move set, dynamic cameras, and a real opponent whose actions are unknown to the player. The goal of this project is to construct a deep neural net that overcomes these challenges and trains an agent to play SSBM at a competitive level.

*Figure 1:* EVO 2016’s SSBM tournament featured 2300 participants and awarded first place over $14,000
For my CPSC490 senior project, I would like to develop a deep neural network that utilizes reinforcement learning to train an agent to play SSBM. I have been a fan of this game for some time both as a player and a spectator of the professional gaming scene. It poses several interesting challenges to machine learning that will be addressed in this project. By utilizing Q-Learning, the network will perform unsupervised reinforcement learning. The Q-Learning algorithm will train an initially “dumb” agent by rewarding certain actions and punishing others. My immediate thoughts in this case are that hitting an opponent will be given some reward; hitting an opponent while in “hitstun”, a state in which the character was recently hit and is currently unable to input a move, will give a greater reward; and killing an opponent will give a maximum reward. Meanwhile, getting hit by an opponent and dying will result in a punishment. However, I would also love to speak with some professional players to better
understand other potential reward strategies. Then, by running several instances of the agent in parallel and allowing it to play itself, the network will gain an in depth training and learn to maximize its reward structure.

Because the project is unsupervised reinforcement learning, the majority of the data will come from the agent’s interactions playing another instance of itself. Additionally, the focus of this project will not be on computer vision and perception. Rather than analyzing screen captures of the game, the data will be provided more explicitly. Player modded editions of the game provide frame-by-frame data on character positions, velocities, etc. This data will be passed as input to the neural network, representing the current game state. I hope to then combine Q-Learning and LSTM algorithms to accurately predict the optimal action for a given state. I believe that passing the past “x” frames (or gamestates) to the network will provide the network LSTM layers adequate information to develop deeper, more complex strategies that otherwise might be overlooked.

Figures 3 and 4: Left: Animation of a SSBM character performing a forward smash, a slower move, requiring 51 frames to be performed. Right: Screen captures of individual frames displaying the hitboxes of the same forward smash attack
Following network processing on the gamestate input, the network will select an output that will map to a given GameCube controller input or combination of inputs. The GameCube Controller consists of 7 functional buttons and 2 joysticks whose inputs vary based on the angle the sticks are tilted. Of these, in terms of SSBM, 5 buttons are necessary and the joysticks can be limited to $x$ potential angles and a neutral (no input) position. Based on computational complexity and computation time restrictions, the number of possible angles will be determined and optimized.

![Figure 5: GameCube Controller with all inputs](image1)

![Figure 6: GameCube Controller with limited SSBM inputs](image2)

Obviously such an endeavor will not be straightforward and will require a great number of iterations in order to optimize. As a result, I would like for a portion of my project to focus on the testing of optimization of reinforcement learning algorithms. I would like to create test scripts to identify optimal hyperparameters (such as learning rate and discount factor) for the given algorithm. Additionally, I would like to experiment with the different applications of LSTM to SSBM. In general there are several universal strategies that are generally effective, but a good SSBM player must also be able to adapt to opponent strategy on the fly and in a short amount of time (just a best of 5 games). I think committing some of my time to testing and optimizing these factors will provide useful, important insights that will help the agent perform even better.
Lastly, I think that comparing results with Benjamin Rodriquez-Vars’s project will give an interesting look into the differences and benefits of reinforcement learning vs. imitation learning. Perhaps the two projects could even be combined to create a truly human-like agent.

To help complete this project, I have compiled several resources to make a project of this scale not only feasible, but also successful. I have read two papers that have explored similar topics and am now in touch with the authors of each, one former PHD student and professor from MIT, and two former Stanford students. I think that this past work not only speaks for the merit and rigorous nature of the project, but will also prove to be incredibly beneficial. This perspective will give me an immediate understanding of existing problems and allow me more time to focus on unique solutions and achieve previously unseen results.

In closing I would like to both discuss both my deliverables and emphasize the project’s importance. First, my goal is present as a deliverable, a trained SSBM agent that can defeat the highest level CPU (level 9) as well as the members of the Smash at Yale club. Aside from this practical application, I would also like to personally gain a thorough understanding of deep neural networks and the difficulties in designing and creating an effective training system. This is a challenging goal, but one that I think I can certainly achieve. Finally, in terms of significance, I believe that this game poses several incredibly interesting challenges to machine learning. Creating an agent capable of learning to play the game at a high level and seemingly understand complex strategy is an exciting problem that will expose a unique community to the capabilities of machine learning.
References and Related Work


EastPointPictures. *The Smash Documentary (Remastered)* [https://www.youtube.com/playlist?list=PLoUHkRwnRH-IXbZfwqgiEN8eXmoj6DlKM](https://www.youtube.com/playlist?list=PLoUHkRwnRH-IXbZfwqgiEN8eXmoj6DlKM)