**Objective:**

* Use reinforcement learning algorithms and techniques to successfully play Ms. Pacman which is a game from Atari 2600. There is currently an available environment for Ms. Pacman and therefore this team will be tasked with implementing different types of deep q-learning techniques to successfully play the game. We will use the available environment instead of creating a new one.

**Environment and Game Information:**

* The Ms. Pacman game was introduced in 1981 and is a sequel to the original Pacman game and therefore the gameplay is similar. The player gains points by eating small balls (pellets) and evading ghosts while traveling throughout a maze. If Ms. Pacman touches a ghost or is touched by a ghost, she loses a life. There are bigger rewards in the maze, that are posters that make the ghosts blue for a certain amount of time, allowing Ms. Pacman to eat the ghosts to gain extra points. The level is complete when all the small balls have been eaten.
* The MsPacman environment offered by OpenAI is a simple interface. The environment represents the state of the game using a 210x160 3-channel RGB image that exposes the developer. The environment provides information on the number of lives MsPacman has left in any given frame and the amount of in-game reward that MsPacman has accumulated over the course of the game.
  + Within a frame, MsPacman has the opportunity to perform one of 9 possible actions including moving left, right, up, down, diagonally, or stay where she was in the previous frame. Each action is performed repeatedly for a duration of k frames, where k can be from 2 to 4.
  + Link: <https://shirsho-12.github.io/blog/rl_gym/>
  + Link: <https://medium.com/analytics-vidhya/how-to-train-ms-pacman-with-reinforcement-learning-dea714a2365e>
  + Link: <https://github.com/openai/gym/wiki/Table-of-environments>
  + Link: <https://www.gymlibrary.dev/environments/atari/ms_pacman/>
  + There are different versions of the environment including: MsPacman-ram-v0, MsPacman-ram-v4, MsPacman-ramDeterministic-v0, MsPacman-ramDeterministic-v4, MsPacman-ramNoFrameskip-v0, and -ramNoFrameskip-v4.
    - <https://towardsdatascience.com/deep-split-q-learning-and-ms-pacman-5749791d55c8> uses Deterministic v4

**Background Knowledge and Feasibility:**

* Convolutional Neural Networks
* Deep Q-Network
  + Takes multiple frames of the games input state values and the actions as output state values
  + Experience replay to store the steps per episode in memory for learning. Where many memory samples are drawn from random repetitions
* According to the the current literature Ms. Pacman is among the lowest performers in terms of playability level when training using DQN and therefore it will require long training times and have access to computing power.
* Explore Double Deep Q-Learning Networks
* Understanding of Huber Loss and RMSprop optimizer or other types of optimizer
* One recommended approach is Deep Split Q-Learning
  + Which can also follow the double deep q-learning method
* Avoidance of ghosts seems to pose a challenge for CNN style Q-Value estimating networks
  + Chronic Pain agent
  + Baihan Lin, Guillermo Cecchi, Djallel Bouneffouf, Jenna Reinen, and Irina Rish. 2020. A Story of Two Streams: Reinforcement Learning Models from Human Behavior and Neuropsychiatry. arXiv:1906.11286 [cs.LG]
  + <https://towardsdatascience.com/deep-split-q-learning-and-ms-pacman-5749791d55c8>
* This project is feasible based on the current available environment and online solutions but it will be difficult to find a way to improve performance in terms of avoiding ghosts and collecting pellets.

**Tasks to be Completed:**

1. Set up and understand the environment
2. Brainstorm other methods to improve performance based on the current literature
   1. (~1 week for 1 and 2)
3. Implement simple DQN for playing the game
4. Evaluate the performance of the DQN for different hyperparameters, etc.
   1. (~2 weeks for 3 and 4)
5. Implement Double Deep Q-learning Network
6. Evaluate the performance of the Double DQN
   1. (~2 weeks for 5 and 6)

**Resources:**

* <https://drpress.org/ojs/index.php/HSET/article/view/6718>
* <https://fse.studenttheses.ub.rug.nl/14915/1/AI_BA_2017_AJTENCAAT.pdf>
* <https://ieeexplore.ieee.org/abstract/document/5286478?casa_token=d1ANSIx0dnIAAAAA:w_gf9Pw_2FHpTQ_JbsJ_3KCaZmzv1i5Rpyo0ZX7AN7t7bLCQgWMpQO5q_4RRm8M2YONlj177DQ>
* <https://ieeexplore.ieee.org/abstract/document/6615002?casa_token=eoLd4VKxWsoAAAAA:Myr8CG4ny1cxNnY93k5Pc7ef9Ee_ldISazbJjOSZ2FX-uGi46CaSl7kTfG6taphWi_H9_CqXxQ>
* <https://link.springer.com/article/10.1007/s11768-011-0272-3>