**Evaluation**

Objective Check

General Objectives

My general objectives involve making sure that the game functions correctly, displays a “game over message” and returns you to the menu screen, allowing you to play the game again.

* **“Create a menu with a single player, local multiplayer, leader board and settings options”. “When a player clicks on one of the buttons, the game state will change from ‘menu’ to ‘playing’”.**
  + I have successfully created a menu with buttons that are interactive and load different parts of the program in.
  + I have only yet to make the “Leaderboard” button interactive, even though it is there, because the online aspect of my game is missing due to time constraints. However, co-op mode was introduced instead of local/online multiplayer.
* **“Create two game modes:” “First game mode will be similar to the original Pacman, but slightly adapted to my style. The algorithms for the ghost AI will be created by me” “The second game mode will be an only local multiplayer game mode, where the player who wins has to survive the longest or get to a specific score (500 points). Lava tiles will spawn temporarily to kill the players, and then eventually the lava tiles will turn into rock tiles. Players can only move over a rock tile, not lava tile.”**
  + I have successfully done this, by creating two different game modes. The only difference is, my second game mode is made for (two player) co-op, not local multiplayer. That aspect of the game changed.
* **“Progression System:” “The game will be able to store the high score of the player” “Players will be able to level up and unlock new Pacman colours or Pacman upgrades”**
  + I have been partially successful with this. I have had a sense of progression to the game by adding a high score option in the settings. However, even though I added in a high score part to the game, I have no added levels that allow for unlockable items/upgrades.
* **“I will be creating various power ups” “These will include ones that affect the player badly or in a good way”**
  + I have been partially successful with this. I have created two different power ups, but both of which are beneficial and are good for the player. I have crated good power ups, but no bad ones.
* **“I will be using arrow keys as the controls. I may also give the player an option to use WASD instead.”**
  + I have successfully assigned arrow keys as the way to control Pacman. In addition, in gamemode two, which is the co-op part of my game, the second player uses the WASD keys.
* **“Difficulty:” “The user will be able to choose a difficulty in the settings menu. The difficulty chosen will either increase or decrease the pace of the game.” “I will develop a cost function to increase the pace of the ghosts as time goes on. Cost function increase rate will change depending on the difficulty.”**
  + I have successfully done this. The cost function I used was an inverse logarithmic function.

Specific Objectives

**Gameplay:**

* **“Assign each tile/cell a value, such as ‘1’, ‘0’ and ‘2’. ‘1’ being the walls, ‘0’ being the free cells and ‘2’ being the enemy spawn point.”**
  + I have successfully done this. This is how I coded my collision detection.
* **“Creating Pacman and allowing him to move UP, DOWN, LEFT AND RIGHT”**
  + This was successfully achieved.
* **“Create a collision detection for Pacman to only be able to interact with free cells/spaces. In addition, the collision detection should allow the ghosts to also only interact with free cells/spaces once they leave the spawn location.”**
  + I have successfully achieved this.
* **“A scoring system will also be put in place. Every game each player will have their individual score being displayed on the screen.”**
  + I have successfully achieved this in both the single-player and co-op gamemode. In the single-player gamemode, the score and lives of the player appears on the left. In the co-op gamemode, player one’s score and lives are on the left side of the screen, whereas player two’s score and lives are on the right side of the screen.
* **“Creating an algorithm/search method for each individual ghost. Most of those algorithms will be complex”**
  + I have successfully done this. I created the Dijkstra algorithm for Inky, Breadth-First Search for Pinky, intersection to intersection movement for Clyde, and random movement for Blinky. Inky, Pinky and Blinky all use the line of sight algorithm also.
  + In addition, I have created a dynamic adjacency matrix algorithm which is the representation for Dijkstra and Breadth-First Search. This allows for the ghost Inky to trap Pacman alongside another ghost; this adds complexity to my game and stops ghosts from directly following each other and taking other directions to try trap Pacman.
  + I also implemented the enemy detection algorithm for my ghosts.
* **“Music and animations will occur.”**
  + I have been successful with this. The music I have played throughout the game. This includes, Pacman eating dots, Pacman dying, a ghost dying, Pacman collecting a power up and just the original Pacman music played in the main menu and settings. The animations in my game are basic, but they are still animations. Some of these include, the lava changing to rocks and the colour of the buttons change to a darker shade when a mouse hovers over it.

**(LAN) Network System:**

*Due to time constraints, rather than a local-multiplayer gamemode, I created a co-op offline gamemode. This still involves more than one player (two players), but rather than the players playing from different computer systems, they will have to play from the same computer system. Hence co-op and not local multiplayer.*

* **“If the user is new, they will create a username and password, which will get stored in the database. The user will have to log in with their username and password. This will carry over their player level to local multiplayer and single player.”**
  + This was not fulfilled as I had no time. The online aspects of my game were not completed due to time constraints. However, the main aspect of my game was the single-player part.
* **“A user may decide to host a game. Players will then be able to see this lobby and click on it to join. When the game finishes, the players wins/losses will be updated in the database and the winner(s) will be shown on the screen.”**
  + I am partially successful with fulfilling this objective. The online aspect objectives, such as hosting a lobby and updating the players wins/losses in the database I have not completed. However, in my co-op gamemode I still display the winner at the end of the game.

**Settings:**

* **“Ability for users to change their Pacman colour. Users will be able to unlock new colours by levelling up.”**
  + I did not create a level system in my game, so I did not implement this.
* **“Users will be able to increase or decrease the volume in the settings.”**
  + I was partially successful with this. The user is able to turn the music on and off, but they are not able to increase or decrease the volume in intervals.
* **“Users will be able to adjust the difficulty of the single-player gamemode in the settings”**
  + I have fulfilled this successfully. Users can change the difficulty, to easy, medium, or hard, in the settings.
* **“Users can get help and advice about the game, in the settings.”**
  + I have successfully created a help button in the settings part of the game.
* **“Users can view their highscore in the settings.”**
  + I have successfully created a button, when clicked on, displays the users high score.
* **“Users will be able to unlock power up upgrades for single player (possibly multiplayer).”**
  + I did not implement power up upgrades, but if I did, the upgrades would increase the time the power up lasts for.

Additional Objectives

* **“A feature which I will implement is making the game from local multiplayer to online multiplayer”**
  + This additional objective was not met. The online multiplayer and local multiplayer were not met. Instead a co-op gamemode was created.
* **“Allow the user to change controls to WASD”**
  + This feature was not implemented.
* **“Pacman will change colour when a power up is activated”**
  + This feature was successfully implemented. Pacman changes to the colour red when a power up is activated.
* **“Create particle affects when Pacman eats dots”**
  + This feature was not implemented.
* **“I will aim to provide a third gamemode where there are two teams. Each consisting of a Pacman and a ghost. The aim would be for the Pac-men to avoid the other teams’ ghost, and for the ghosts to try consume the other teams Pacman.”**
  + This is the least important additional objective as it is very time consuming, and does not add extra complexity to the game. I currently have not implemented this feature.
* **“Allow for map creation/generation”**
  + This feature is not implemented, but it would allow for various levels, and it would add a great amount of creativity and uncertainty to the game.

User Feedback

Users of all ages tested my game. In addition, a lot of the users that tested it, were people I do not know, or have met once. This creates objectivity rather than subjectivity.

* The game was very easy to setup and launch.
* The main menu was very easy to interact with, as the mouse movement was smooth, and when the mouse was hovering over a button, it would highlight it by making it a shade darker. This especially helped people of old or young age, interact with my game in the main menu screen.
* The mood (including music and graphics) made it feel like an authentic classic Pacman/Arcade game.
* The controls are simple and very easy to use when playing the game, or when navigating around the game/program.
* Ability to change controls in the settings would be a good feature to implement.
* The graphics could need improvement. This includes the ghosts, Pacman, lava tiles and rock tiles.
* More advanced animations are needed, such as particle effects or Pacman as a sprite munching on the dots rather than Pacman just being a yellow dot.
* Player movement does not feel smooth when transitioning between tiles. (This can be improved using interpolation).
* The power ups are very responsive when activating.
* The current power ups are good, but a bigger variety would be better.
* The pace of the game increasing (using my cost function) really makes the game more intense and fun to play.
* Allowing players to change the difficulty really allows unexperienced or experienced players to play at their level.
* People that tested my game especially said how it would be amazing if they could play each other around the world, so online multiplayer. Even local multiplayer would make the co-op experience much better.
* The users were really pleased they could see their high score in the settings. This made them feel a sense of achievement. The game felt like it had a “goal”, which is to beat your current high score.
* The help option in the settings helped new users understand how my version of Pacman works.
* The idea that the lava tiles spawn in random locations on the map make the game intense and interesting. The lava tiles are a very interesting feature, alongside with the fact that they turn into rock tiles after a period of time.
* Adding different types of tiles other than lava and rock would certainly make the second gamemode less repetitive.
* After explaining my algorithms to some users with experience in computer science. My algorithms being, Dijkstra, Breadth-First Search, Line of Sight and a dynamic matrix algorithm for the ghost that uses Dijkstra. After mentioning these algorithms, some users suggested using A\* Search also, or replacing Dijkstra with A\* Search.
* The current complex algorithms made the ghosts feel just as smart, if not smarter than the original Pacman game, which made the game more challenging and fun to play.
* Users suggested for an online Leaderboard.
* Sprites of ghosts and Pacman, rather than circles being drawn to the screen.
* The user should have a profile where the amount of games played, wins/losses on co-op mode and high score are displayed. In addition, each user should have their own username, so multiple users can play on the same device while retaining their own high score.
* Game is very easy to understand. This was not only due to the help option in the settings, but also the visible text on the screen. Some of this visible text showed if the user was carrying any power ups, the users current in game score and also the amount of lives the user currently has.

Potential Improvements

* **Controls/UI:**
  + Add an option in the settings to change and customize the user’s controls.
  + Add the option to fully customize key bindings. This means, the user is able to map individual keys, rather than just choosing a set of controls.
* **Gameplay:**
  + Create more variety of power ups.
  + Add particle effects. For example, when Pacman is eating dots, or when a ghost or Pacman dies.
  + A key improvement would be to add interpolation to create much more smooth movement in my game.
  + Rather than the second gamemode being co-op offline, I want to make it co-op online (local/online multiplayer). I couldn’t do this improvement in time due to time constraints but I plan on doing it in the future.
  + I will be able to add a leaderboard using a mySQL database. This leaderboard would track all users high scores from around the world. This database would have to be on a central server and would add another online aspect to the game.
  + Add other tiles other than lava and rock, on the second gamemode. I could add a water tile, which would increase the speed of the user, when they go over it.
  + Map generation is also something that I could add. This would make the game more spontaneous and therefore exciting. A random map would be generated and all my current functions are catered for any random map generated, so this would not be too hard.
  + I could add sprites with animations rather than just drawing Pacman and the ghosts as circles. These animations could be Pacman eating the dots.
* **Settings:**
  + Add a slider for music. This is so the user can increase or decrease the music, rather than just being able to turn it on and off.
  + I would be able to add unlockable customizable Pacman skins, new Pacman levels, and maybe even new music sounds.
  + I should add a wins/losses option in the settings where the user can see how many local/online multiplayer games they won. Would only be able to do this, if I make my game local/online multiplayer. Currently my game is co-op offline, so two users can play, but from the same computer.
* **Local/Online Multiplayer:**
  + My game is currently local co-op, which means that multiple players are able to play, but only on the same computer.
    - If I made my game local multiplayer, players on the same network but different computers would be able to play.
    - If I made my game online multiplayer, players all around the world would be able to play.
    - If I made my game either local or online multiplayer, a mySQL database would be created to hold each users profile.
    - Implement a ranking system, which could also be applied to Singleplayer. This ranking system would be based around levelling.

Analysis

Overall, I believe my project was successful. The game functions exactly how I said it would, besides my second gamemode, which was expected to be local multiplayer was instead created as a co-op gamemode. This was due to time constraints as I did not expect the complex algorithms for the ghosts to take as long as they did. However, I did still create a second gamemode that can be played by multiple players, but does require those players to be on the same computer system.

Most users who tested the game gave positive feedback. The users said that my User Interface was easy to use and the controls were simple and easy to get a grasp of. In addition, users said they found the gameplay very fun, intense and an exciting adaptation to the original Pacman game. Users especially enjoyed how the game speed up as the score increased, using my cost function (an inverse logarithmic function).

However, many users said there could have been various improvements to my game. A very popular improvement that many users mentioned, was making my second gamemode local or online multiplayer, so users can play each other on different computers, rather than having to play each other on the same computer. Other improvements users mentioned were to make the game smoother, which would need interpolation in between the movement of tiles. Users also specified how they would like an online leaderboard as well as more animation during the game.

The most difficult part of the project was creating the complex algorithms for my ghost. My path finding algorithms involved creating an adjacency matrix and an adjacency list. To create the adjacency matrix and adjacency list, I had to store all the nodes (which are the intersections of the maze) and then parse through the vertices of these nodes into the matrix/list. Parsing the vertices was a very complex task, but it increased the efficiency of the path finding greatly. For example, by parsing just the intersections, Dijkstra would look through a maximum of 4096 possible paths, instead of a maximum of 82,944 possible paths. By creating the adjacency matrix/list, not only did I have to figure out how to parse into a matrix/list, but I also had to figure out how to implement XOR in my program. Furthermore, coding the actual algorithms, Dijkstra, Breadth-First Search, line of sight algorithm and dynamic matrix algorithm, were very complex. These complex tasks taught me more about how path finding and searching algorithms work, and how they can be applied to so many real-world applications, such as google maps.

If I were to do this project again, I would most likely spend less time on creating extras, especially in the user interface (such as shading the button when the mouse hovers over it). Instead I would spend more time in creating the second gamemode into an online multiplayer gamemode where users all around the world would be able to play from different computers. I would also spend time on creating more variety of power ups, alongside the two power ups I currently have.

If I were given a few more months to work on this project, I would firstly create a local/online multiplayer for the second gamemode rather than what I currently have. Secondly, I would improve the graphics of the game, by making the lava and rock tiles not just coloured rectangles, and also add particle effects to them too. In addition, I would replace drawing Pacman and the ghosts as circles, with actual sprites that are animated (such as Pacman eating the dots). Lastly, I would create an online leaderboard that shows the players wins and losses, and also the players high score (the players would be able to filter what they want to see on the leaderboard).

Finally, I would like to make my game less repetitive by adding more of a variety of power ups and implementing map generation. Map generation especially would make the game more spontaneous and exciting as every game would be a different map. The functions in my game are built for any maze generation as none of my functions have hard coded values directly for the maze I have built. Conclusively, rather than playing the same maze over and over again, different mazes would be generated every time.

Bibliography

Here is a list of resources used in my project.

Pygame: <https://www.pygame.org/>

NumPy: <https://numpy.org/>

Anaconda (environment interpreter): <https://www.anaconda.com/>