User Manual

CA400

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Abstract

AIRace demonstrates how machine learning can be used to drive cars autonomously. I developed two neural network algorithms, backpropagation and NEAT (NeuroEvolution of Augmented Topologies) a genetic algorithm to train the cars using inputs from its sensors. A vehicle pathfinding algorithm provided by Unity is also implemented in AIRace in order to contrast the best case scenario without using machine learning. This project determines which one performs best under particular scenarios. To showcase these algorithms I created a 3D racing game, where a user can either play by themselves or race against other cars controlled by said algorithms. More advanced users can observe the training process of either algorithm and experiment with various attributes pertaining to them. In this document, you will find a detailed outline describing how to navigate and play AIRace. Instructions on how to download, install, launch and uninstall the game. Finally, a description of how to operate the Learning Mode, what each attributes means and the optimum values for a given scenario.

1. Introduction

AIRace is a 3D racing game targeted at computer gamers and racing game enthusiasts, the game aims to enable users to drive around the track, either on their own or race against enemy cars. Enemy cars are driven by three separate algorithms, backpropagation, NEAT (NeuroEvolution of Augmented Topologies) a genetic algorithm and a pathfinding AI. AIRace was created using the Unity Game Engine, it implements two main features, Racing and Learning mode.

Racing mode focuses on the user interaction with the car and track, enabling a smooth and realistic gaming experience. AIRace uses custom car physics, including acceleration curves, steering, drag and camera movements which provides an authentic and unique driving experience. The user is able to select between a set of different cars, each of these cars will have different speed, handling and drivetrain characteristics. Within Racing mode, the game contains two separate features, timetrial and competition. In a timetrial, a user can race around a track on their own trying to beat their best time or practice for a future competition. In a competition, they will face against enemy cars which use the aforementioned algorithms to drive around the track.

Learning mode allows users to visualise how the computer learns to go around a track. They can choose between genetic or backpropagation algorithms and experiment with various attributes pertaining to them such as fitness functions, mutation probabilities, learning rates, sensors lengths and population sizes. Experimenting with these attributes will show which one performs best under particular scenarios, allowing the user to compare both algorithms and their attributes.

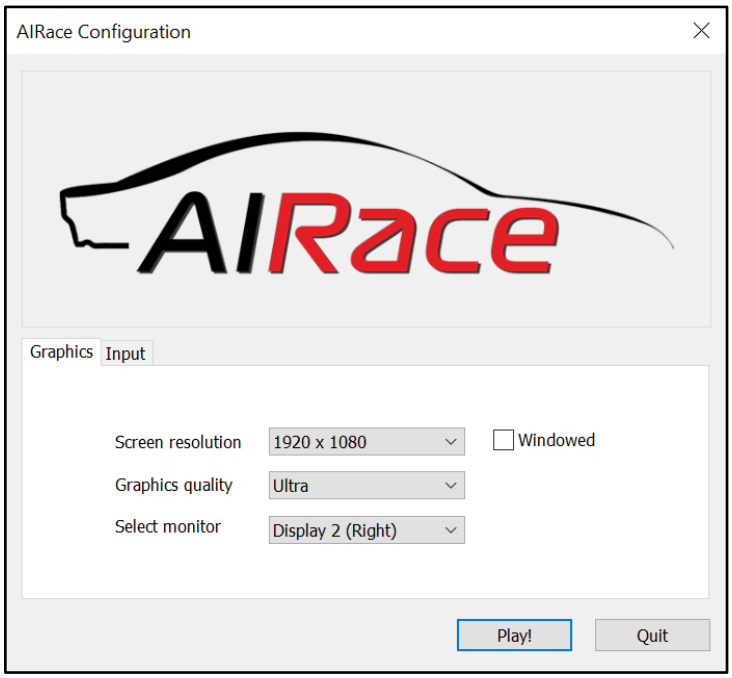
2. Getting Started

2.1 Requirements

- Windows Computer
- Access to Gitlab
- Suitable computer graphics performance to run a game (recommended).

2.2 Download

1. Open the following link: https://gitlab.computing.dcu.ie/khaletk2/2019-ca400-khaletk2/tree/master/build
2. Here you will find a folder called “AIRace”.
3. Download the entire folder to your Windows Computer.
4. Open the folder and run the executable called “AIRace.exe”.



You will see a configuration window as shown in the screenshot above. Here you can select your display size and change whether you want to run the game in fullscreen mode or windowed. It is recommended to play AIRace on a computer with good graphics capability to be able to enjoy the game at its full potential. Graphics quality is recommended to be set to “Ultra”, but if the game seems to lag or stutter then quit the game and lower the graphics quality until the game is running smoother. When you are ready to start the game press “Play!”. If you wish to return to desktop simply click “Quit”.

2.3 Uninstall

If you wish to uninstall or remove AIRace you can simply delete the folder named “AIRace” which you have previously downloaded.

2.4 Main Menu Navigation

When you start the game you will be greeted with the following screen. Here you will find four buttons which perform the following:

- **Learning Mode -** Opens Learning Mode (Section 4).
- **Racing Mode -** Opens Racing mode (Section 3).
- **Help -** Opens the Help section (Section 5).
- **Quit Game -** Quits the game and returns you to your desktop.

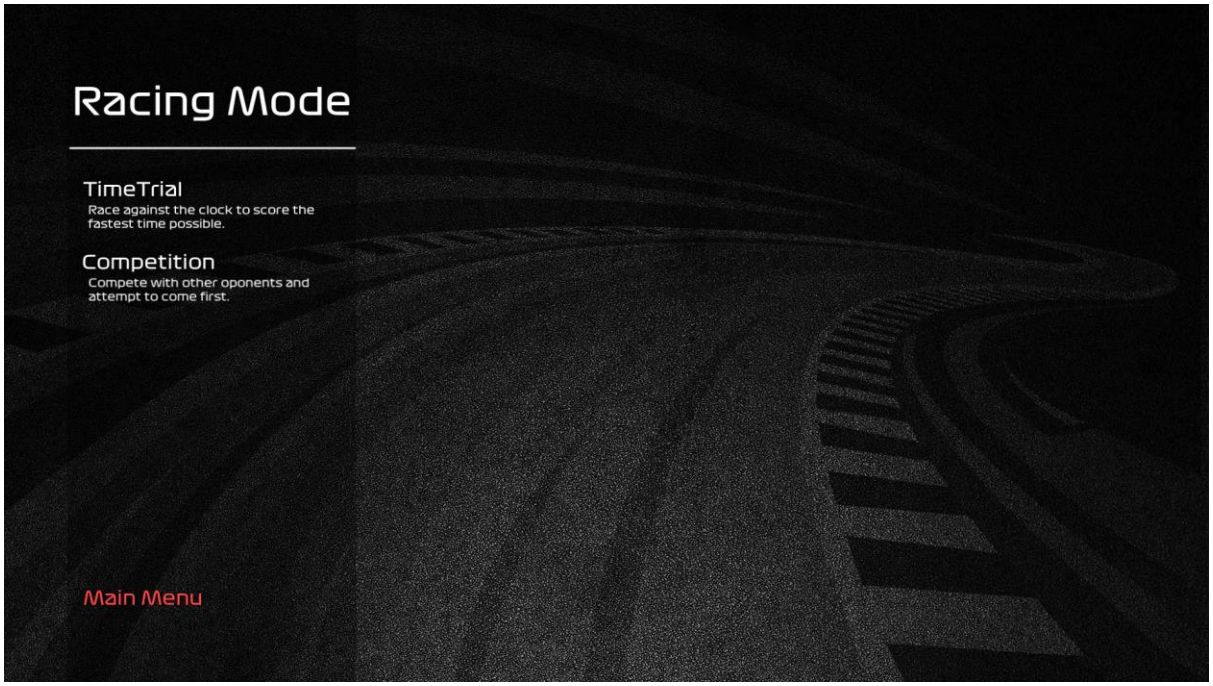
See each individual section for further details on each feature.

2.5 Controls

Action	**Button**
Accelerate	W/Up
Reverse	S/Down
Turn Left	A/Left
Turn Right	D/Right
Brake	Space
Pause	Esc

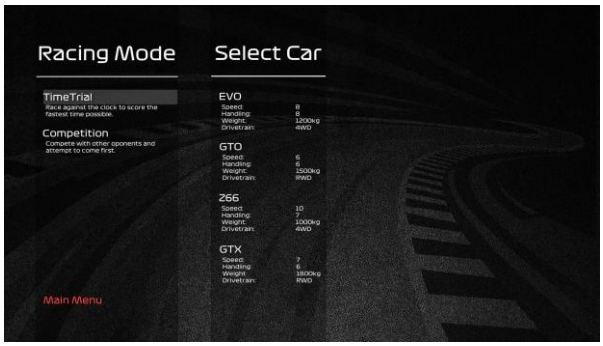
To interact with buttons, sliders and dropdown menus please use your mouse.

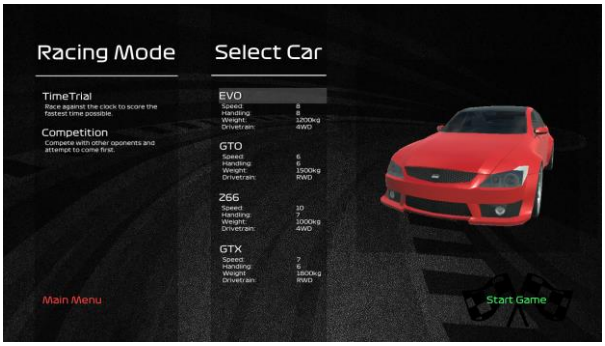
3. Racing Mode



Pressing the “Racing Mode” button on the main menu will bring you to the Racing Mode selection menu. Here you can choose between a “TimeTrial” and a “Competition”. If you wish to return to the main menu you can do so by clicking on the “Main Menu” button highlighted in red down the bottom.

3.1 Time Trial

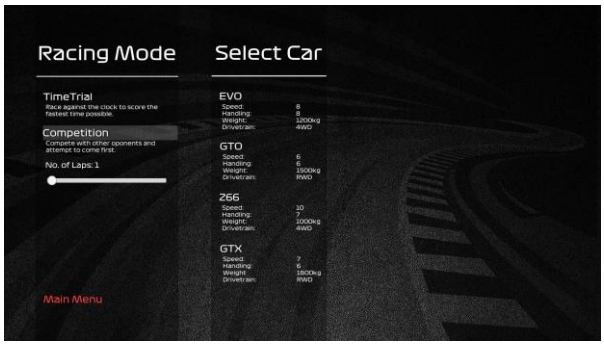


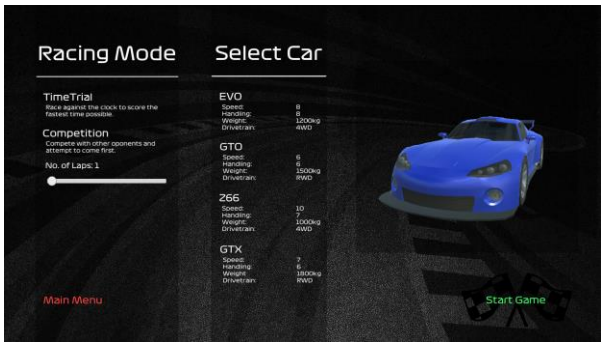


If you choose to play the “TimeTrial” mode you are presented with a list of cars to choose from. Details about the car are given such as Speed, Handling, Weight and DriveTrain. These attributes should give you an idea of how the car will perform and help you choose the best car for you. When you select a car it will show up in the “Showcase” window, where you can see the car itself and the “Start Race” button will also show up. This button will allow you to start the mode you selected. If you wish to choose another racing mode or another car you may do so.

When in a game you will see a countdown timer, and once it's over your controls are activated and you are able to drive the car (Please see section 2.5 for car controls). On this screen, you will also see your current speed (shown in km/hr), current lap count, your current lap time and your best lap so far (shown in the screenshot above). To exit to the main menu simply bring up the pause menu and press “Main Menu”. You can see how to navigate the pause menu in further detail in section 5.

3.2 Competition



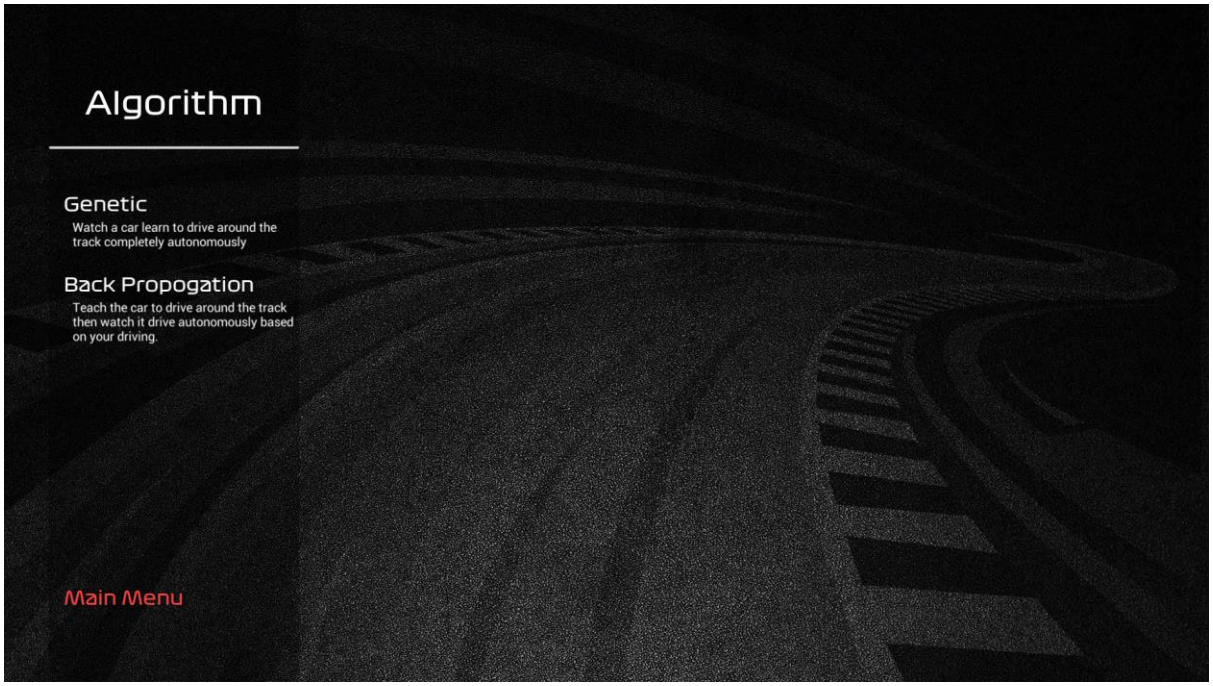


If you choose to play the “Competition” mode you are presented with a slider from which you can choose how many laps you want the race to be with a list of cars to choose from. Details about the car are given such as Speed, Handling, Weight and DriveTrain. These attributes indicate how the car will perform and help you choose the best car for you. When you select a car it will show up in the “Showcase” window, showing the car itself and the “Start Race” button will also show up. This button will allow you to start the mode you selected. If you wish to choose another racing mode or another car you may do so.

When in a game you will see a countdown timer, and once it's over your controls are activated (Please see section 2.5 for car controls). On this screen, you will also see the current speed (shown in km/hr), current lap count out of the total laps in the race, your current position in the race. In competition mode, you will now see three other opponents which will try beat you to the finish line, when you overtake an opponent your race position will change to the place of your opponent and vice versa. To exit to the main menu simply bring up the pause menu and press “Main Menu”. You can see how to navigate the pause menu in further detail in section 5.

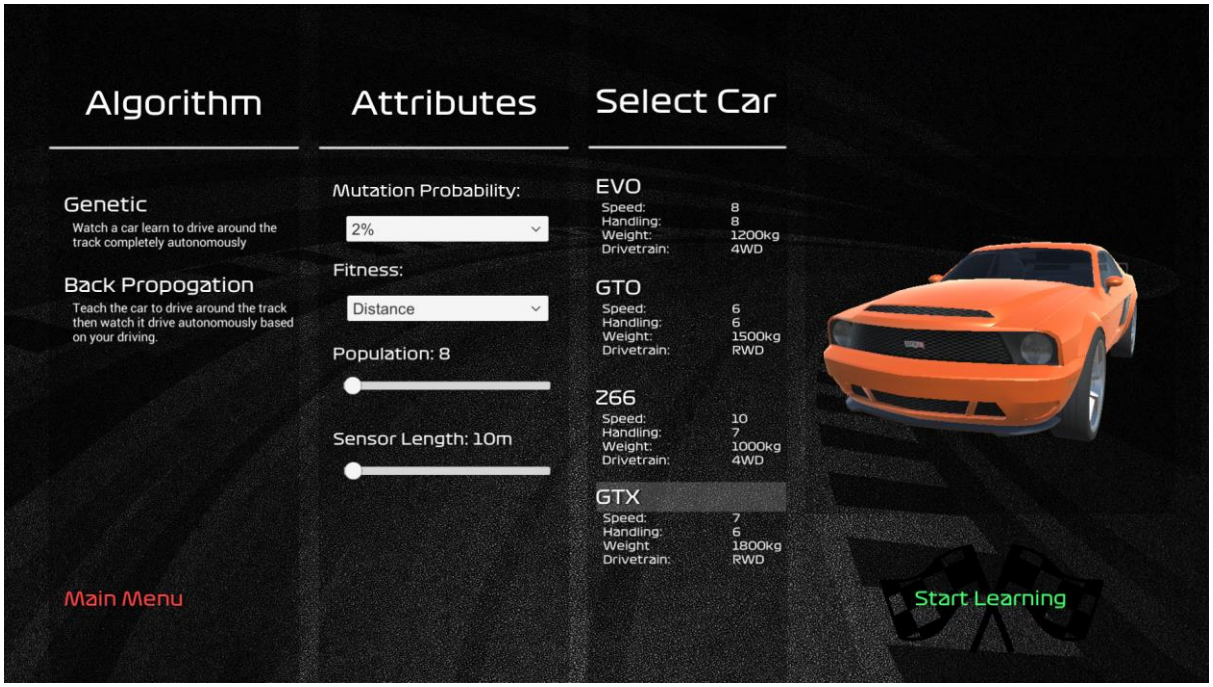
When you complete all the laps you will be shown the finish screen, where you can see your position and return to the main menu using the “Main Menu” button highlighted in red.

4. Learning Mode



Pressing the “Learning Mode” button on the main menu will bring you to the Learning Mode selection menu. Here you can choose which algorithm to train the car with. You can choose between a “Genetic” or “BackPropagation”. If you wish to return to the main menu you can do so by clicking on the “Main Menu” button highlighted in red down the bottom.

4.1 Genetic



If you choose “Genetic” the screen above is presented. Here there is a list of attributes which you can change about the algorithm, these include:

- **Mutation Probability -** Changes how often a child will be mutated.
- **Fitness Function -** Changes how the fitness of the children should be calculated.
    - **Distance -** Longer distance of travel correlates to higher fitness.
    - **DriveTime -** Distance of travel in a given amount of time correlates to higher fitness.
    - **LapTime -** Better lap time correlates to higher fitness.
- **Population Size -** Number of children to be born in each generation.
- **Sensor Length -** Length of the sensors in a car.

Optimal Values

Attributes	Fastest Lap Times	Quickest Learning
Population	20	30
Mutation	5	10
Sensor Length	30	40
Fitness	LapTime	Distance

Next, you can choose the car to train the algorithm on. Similar to “Racing Mode” each car has different driving and handling characteristics, therefore the algorithm will be trained to suit each individual car differently. When you have finished all configuration the “Start Learning” button highlighted in green is pressed to proceed. If you wish to choose another learning mode or another car you may do so.

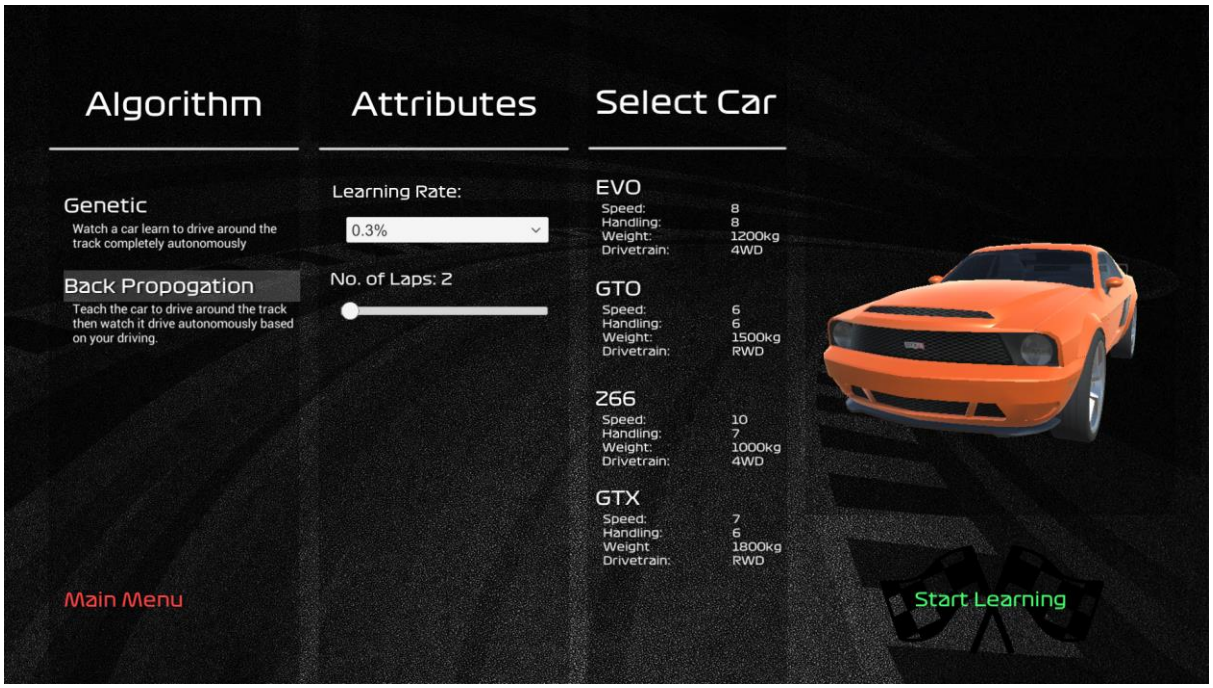
When in Genetic Learning Mode you will begin to see the car learning to drive around the track autonomously. On the right side of the screen, you will see the current speed, current

time and best time as usual. On the left side of the screen, you will see various attributes pertaining to the algorithm such as:

- **Mutation Probability -** How often a child will be mutated.
- **Current Generation -** Number of the current Generation.
- **Mother -** Second most fit child of the previous generation, this value will be set to "None" when it's the first generation and all children are random.
- **Father -** Most fit child of the previous generation, this value will be set to "None" when it's the first generation and all children are random.
- **Current Child -** Number of the child currently driving the car.
- **Steering -** Steering output of the current child.
- **Engine -** Engine output of the current child.
- **Fitness -** Fitness of the current child (how fit it is).
- **Population -** Size of the population of children to be born every generation.
- **Children List -** List of children who have died (crashed) and their fitness values.

Down the bottom you will see a timescale slider, this slider changes the speed at which the game will run if you want to speed up the time at which the car is learning at just slide it across. The "Next Child" button will kill the current child and go straight to the next child in the generation. You can continue watching the training process for an unlimited amount of time. To exit to the main menu simply bring up the pause menu and press "Main Menu". Navigating the pause menu is dealt with in more detail in Section 5.

4.2 BackPropagation



If you choose "BackPropagation" you will be presented with the screen shown above. Here you will see a list of attributes which you can change about the algorithm, these include:

- **Learning Rate -** Smoothing rate to stop the weight going in big (chaotic) steps.
- **No. of Laps -** Number of laps that the user will drive to teach the algorithm.

Next, you can choose the car to train the algorithm on. Similar to section 4.1, after selecting the attributes and car you can proceed by pressing the “Start Learning” button.

When in BackPropagation Learning Mode you will be presented with a screen similar to “TimeTrial” as shown in section 3.1. You will drive the car for a given number of laps depending on how many you have selected on the previous section (Please see section 2.5 for car controls). Drive carefully and avoid collisions. After you finish the number of laps you set you will be presented with the screen shown in the screenshot above. The system prompts the player to release all input, and hopefully, the car has been trained successfully to begin to complete laps. At the bottom of the screen, the Steering and Engine output values from the algorithm are visible. There are two buttons, “Reset Car Position” will reset the position of the car if it crashed into a wall and is stuck. “Restart Learning” will restart the entire process and you will be able to drive and train the algorithm again. To exit to the main menu simply bring up the pause menu and press “Main Menu”. You can see how to navigate the pause menu in further detail in section 5.

5. Pause Menu

When in a game the “Esc” key on your keyboard causes the game to puase. Doing so will bring up the “Pause Menu”. From here you can perform the following actions by clicking on them with your mouse pointer:

- Resume - Closes the Pause Menu and returns you to the game.
- Help - Opens the “Help” section (see Section 6).
- Main Menu - Returns you to the “Main Menu”.
- Quit Game - Quits the entire game and returns you to your desktop.

Alternatively, you can close the pause menu by pressing “Esc” on your keyboard.

6. Help Section

Opening the “Help” section will show you the following screen. From here you can check how to control a car, read about the various modes, check the game credits all directly from AIRace.