A project submitted in partial fulfilment of the award of the degree of Bsc (Hons) Computer Games Programming From Staffordshire University

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A Self-Driving Neural Network to handle multiple off-road terrains

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# Introduction

## Aims and objectives (of the report)

* Objectives of the report
  + Research Ethical and legal considerations
  + Research project management and methodologies
  + Background Research into Self-driving cars
  + Design and implementation documents for the software artifact
  + Full program listing
  + Test Results
  + Analysis and evaluation of the project

## Legal and Ethical Considerations

* None as it does not physically effect anyone as it is a simulated car in video games
* does not Affect human or animal participants
* Does not represent an indirect risk to non-participants
* The research does not reuse any previously collected personal data.

## Risk Assessment

* Tiny risk as it does not affect any other person apart from the developer
* Mainly Desk Ergonomics

## Project Management

### Considered Methods

* Agile
* Waterfall

### Chosen Methods

* Agile
  + Lots of first with python and TensorFlow and UE4
  + Will run into some issues
  + Will have to adapt to them

# Context and Preliminary Investigation

## Project background

### Identification of the problem

* Games are becoming more and more realistic year after year, When AI cars are still very static just following a pre calculated path.
* This removes emersion in driving games.
* This is visual in off road terrains

### Project Rationale

* With new hardware advancements (RTX 30 series and RX 6000), Specific cores for raytracing and AI have been implemented allowing more complex AI simulations to occur without effecting graphical performance.
* This extra power can be leveraged to improve AI.

## Investigation method

* Researching (Researching involves gathering and analysing other people’s opinions or scientific findings to answer a question)

## Project Planning

* Used a Gant chart (LINK TO APPENDIX).
* Scope
* Evaluation Criteria (from proposal)

# Analysis

## Problem Solving method

NO IDEA--------------------------------------------------------------------------------------------------------------------------

## Analysis method

NO IDEA--------------------------------------------------------------------------------------------------------------------------

# Design

## Tools Research

### Engine

* Important choice as it effects the usability of the end project

#### Unity

* More used by indie developers
* Uses C#
* Already supports Neural Network Driving

#### Unreal

* Has premade advance car template
* Uses C++

#### Chosen Engine

* Unreal
  + C++ use
  + Premade Car template

### API

#### TensorFlow

* Open source
* Very flexible
* Multiple API layers using TensorFlow, Keras etc.

#### OpenAI

* More used for text and image-based applications
* No support in unreal
* In private beta

#### Chosen API

* TensorFlow
  + Has plugin for ue4
  + Allows GPU acceleration
  + Backed by google
  + Large community of developers
  + There is a new C++ version that could be used in the future

# Implementation

## Overall Structure

### C++

* Takes Care of car
* Takes Care of score
* Takes Car of reset
* Takes Care of steering
* Takes Care of formatting input

### Blueprints

* Handles all communication from c++ to python

### Python

* Handles all TensorFlow /AI code

## Car System

### Sensors

* 8 Ray cast sensors set up in nautical direction
* Max distance of 0-10,000

### Score

* To score the AI agents other Neural networks created a score
* Universal score to compare all AI setups agents’ other versions
* Score Via distance and a lap multiplier

## Neural Network Version one

### Features

* Simple get something working and test a few values that I hand place

### Usefulness

* Not best but very simple to understand and read the file

## Neural Network Version two

### Features

* All features of version one with auto testing multiple values

### Usefulness

* Very useful as automatically test all possible elements

## Neural Network Version three

### Features

* Quick Test to see if back propagation was working correctly so used genetic algorithm to teach the AI

### Usefulness

* Useful to prove AI input was wrong and not teaching,

# Testing

## Testing Method

* Comparing similar situations in games, this is simple and understandable
* Compared with ----- GTA V
* Use Score to find best score ()

## Testing planning

* Compare Similar situations from GTA to artifact

## Conclusion From Results

* Very Bad like very very bad

# Critical Evaluation

## Success of the project

### Project Management

* Good but can be better with more options if issues occur

### Research

* Research was good
* Multiple sources
* Multiple formats
* Should of looked more into non visual AI implimentation

### Implementation

* Bad as couldn’t get it running properly (not even going in a circuit)
* Good AI auto testing
* Good Robust c++ and blueprint systems
* Good for first time using TensorFlow, python, blueprint and (properly using) UE4

## Experience Gained

### Academic Skills

* High
* First ethical consideration
* Frist large paper written
* First research paper

### Professional Skills

* Don’t Know-----------------------------------------------------------------------------------------------

## Repeat of the project

* Reduced Scope
* Plan for multiple issues

## Extra Features

* Work on more terrain support
* More Support (Currently only works on systems with Nvidia GPUS and required Nvidia development tools)

## Value of the project about professional and academic expertise

# Conclusion

# Bibliography

23/10/20, :. h.-n.-z. T. k. U. S. o. a. l. n. n. n. a. D., Date: 23/10/20. *: https://www.asimovinstitute.org/neural-network-zoo/ Type: knowledge Use: Summary of a large number neural network architectures Date: 23/10/20.* [Online].

# Appendix

PROJECT HANDBOOX AND EXSAMPLE PROJECT