Coursework Portfolio

AINT153PP Intelligent Systems

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1 Big Data

Report: Big Data in Sport

1.1 Introduction

This document will explain how big data can be used within sport, and how these scenarios are implemented to improve an athlete's performance. It will also explain the main issues that are derived from using big data to analyse one's performance within their chosen sport. It will not relate to one specific sport; but instead generalises the use of big data in many sports. This is done since there are different views and opinions on whether data analysis should even be considered in sport.

1.2 Application Area

In sport, training is extremely important and forms an essential part of all athlete's daily routines. This excessive amount of training is for the sole purpose of the athlete improving and developing one's abilities, in their desired physical activity. Competitive athletes would reach extreme situations in order to reach optimal results and have a chance to be selected for a prestigious competition. There are many different methods for collecting data from athletes and will also depend on the type of sport. For instance; by using big data it is possible to collect footage of every action and movement that an athlete makes. This is done by having multiple cameras set up in different positions to capture every angle of movement. This can be implemented into many different scenarios, depending on the type of sport that has been chosen.

One other main application of big data in sport; is monitoring an athlete's biological functions. This includes but is not limited to; heart rate, oxygen intake, carbon dioxide output, and blood pressure. Once these statistical values have been collected; they can be analysed by both the coach and athletes. As a result, it could influence a different coaching method that is made on more advanced athletes, such as Olympians. The goal of this, is to use the data in an effort to gain a competitive advantage.

However; big data is not only used for producing statistics on how to improve one's performance, but also contains uses in sport that are useful to spectators. For instance; in Ten Tors, each team is required to carry a piece of equipment that relays their location to the members of staff in charge of tracking teams' whereabouts. They will monitor the speed and coordinates of each team, to ensure they do not cheat, nor wander into forbidden territory.

1.3 Key Challenges

At the 'LawInSport' Annual Conference, both sport and legal professionals discussed the possible approaches to how sport organisations must handle the capturing and distribution of data. And the legal challenges associated with the new 'EU General Data Protection Regulation'; and the privacy issues that will arise due to capturing data of athletes. With the rise of popularity in big data, new legislations are being created to ensure the information obtained is not use unethically or unfairly. This is due to the vast amount of sensitive information that is contained in big data. As a result; this data

should be treated similarly to how a business handles their customers' information; fairly and ethically. Due to these added data protection regulations, it may create some obstacles for prestigious sports clubs, and therefore they may be required to adapt to new rules of capturing data of athletes.

Big data also creates some ethical issues that will need to be addressed to improve how big data is used in the world of sport. The use of equipment to capture the movement of athletes is generally expensive and thus creates an unfair advantage to the sports clubs that are capable of purchasing this equipment. This raises a concern of whether it is ethical or not, due to the competitive advantage that prestigious clubs will have over smaller ones. However; it is debatable; as it is not considered as cheating, although is restricted to prestigious sports clubs. This means only specific athletes will have access to these advanced resources, therefore it will be more difficult for smaller sports clubs to acquire the equipment required for data analysis.

1.4 Open Issues

Before every major competitive event, athletes' blood and urine is tested to contain any chemicals which indicate the use of performance enhancing drugs. However; certain athletes are able to manipulate the data from these tests, by following specific procedures. With each drug, requires a different procedure to counteract the effects; and thus, appear normal. New methods are continuously being created, and it is becoming ever more difficult to classify the traces left behind as a result.

It is unethical for athletes to use performance enhancing drugs to win, as it is unsportsmanlike. This issue needs to be addressed, because of how it creates a dishonest and improper advantage to competitors. For instance; the drug Erythropoietin is used by athletes to increase the number of red blood cells in their circulatory system which can carry oxygen. Lance Armstrong was able to take small quantities of EPO, so it wouldn't be detectible in a urine sample; however, the drug drastically reduced the percentage of water in the bloodstream, and this is how testers would identify who has taken the drug. Armstrong was able to manipulate the data by injected water into his circulatory system to ensure his blood was 50% water. Due to this, I personally believe that Big Data Analysis will be extremely important in the future, due to the major advancements that will occur within sport.

1.5 Conclusion

In conclusion, big data is a major advance in sport, and will be crucial for analysing athletic performance. New technologies have significantly changed both the way we view sport, and the methods we use to coach athletes. I believe that data analysis is currently at the start-up stage in sport and will eventually evolve to become common due to its reliability and accuracy. In the future, it will also help against thee known issues of cheating; picking up patterns that humans cannot single out. This relates to when athletes make phenomenal improvements that are impossible, and thus the program would identify who is taking performance enhancing drugs.

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2 Brain Modelling

Report: Neural Networks

2.1 Introduction

The purpose of this report is to explain my approach of training a neural network to classify specific shapes and lines. To perform this, I am using the program “Multiple Back-Propagation (MBP) Version 2.2.4”. Initially, four shapes have been implemented into the training and test sets, and I am required to add two additional shapes that the neural network must identify. I will then analyse the results and determine the best structure for training the neural network. The ‘Learning Rate’ and ‘number of hidden nodes’ are the independent variables in this test.

2.2 Method of Approach

The four shapes that have already been implemented into the training and test sets are: horizontal, vertical and diagonal lines. There are two different types of diagonal lines; one approaching North East, and the other approaching North West. The shapes I have decided to add are a 4x4 circle and a 3x3 square. I have made it that the square is three pixels wide and the circle is four, as there will be some difficulty for the neural network distinguishing the difference between the two shapes if they were the same length. The circle will be quite basic, as the pixel grid provided is only 4x4 pixels.

```
0 1 1 0
1 0 0 1
1 0 0 1
0 1 1 0
```

Circle

```
0 0 0 0 1 0
```

```
1 1 1 0
1 0 1 0
1 1 1 0
0 0 0 0
```

Square

```
0 0 0 0 0 1
```

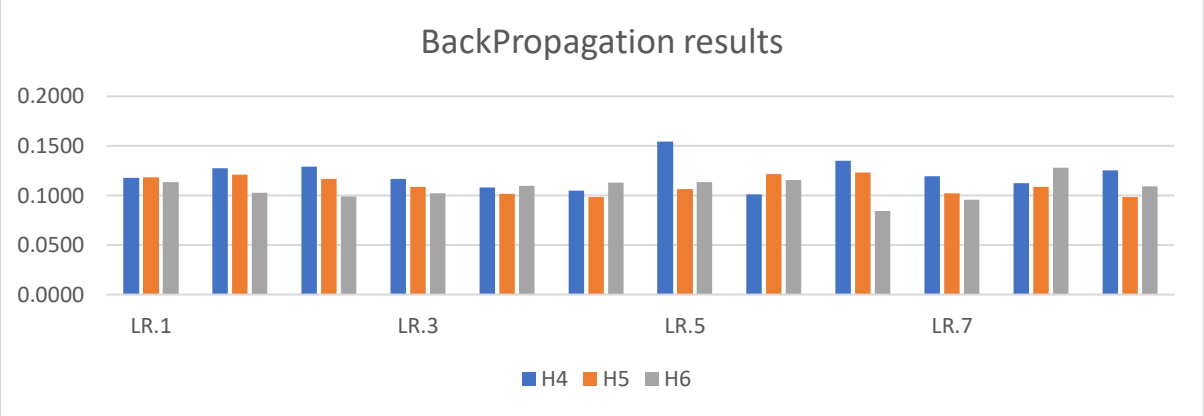
Due to the square being three pixels wide and long, it is required to be placed in different locations of the pixel grid. This is crucial because it will help the neural network identify the shape, regardless of where it is located on the grid. If this is not implemented, the neural network will find it challenging to identify the square when it is not in the original position.

2.3 Testing Results

The testing results shaded green are the four lowest values, and the ones shaded in red contain the four highest values. This will allow for a better presentation of the Neural Network results, and thus more easily be able to identify the best learning rate combined with the number of hidden nodes. The largest testing values are: LR.5 & H4 of 0.1544 and 0.1347, LR.1 & H4 of 0.1291, and LR.7 & H6 of 0.1282. The lowest testing results are: LR.5 & H6 of 0.0842, LR.7 & H6 of 0.956, LR.3 & H5 of 0.0984, and LR.7 & H5 of 0.0984.

	H4	H5	H6
	0.1177	0.1183	0.1136
LR.1	0.1274	0.1210	0.1026
	0.1291	0.1165	0.0987
	0.1166	0.1084	0.1020
LR.3	0.1079	0.1015	0.1097
	0.1047	0.0984	0.1131
LR.5	0.1544	0.1067	0.1137

	0.1009	0.1215	0.1156
	0.1347	0.1230	0.0842
LR.7	0.1192	0.1022	0.0956
	0.1125	0.1086	0.1282
	0.1252	0.0984	0.1093



2.4 Analysis of Results

Unfortunately, there is no clear indicator of a structure that produces the best results, when changing the independent variables for the neural network. However; by calculating the average and standard deviation of each section, it will allow a better understanding of which variables may be the most efficient for training and testing the neural network.

	H4	H5	H6
LR.1	Average	Average	Average
	0.1247	0.1186	0.1050
	SD	SD	SD
	0.0062	0.0023	0.0077

	H4	H5	H6
LR.3	Average	Average	Average
	0.1097	0.1028	0.1083
	SD	SD	SD
	0.0062	0.0051	0.0057

	H4	H5	H6
LR.5	Average	Average	Average
	0.1300	0.1171	0.1045
	SD	SD	SD
	0.0271	0.0090	0.0176

	H4	H5	H6
LR.7	Average	Average	Average
	0.1190	0.1031	0.1110
	SD	SD	SD
	0.0064	0.0052	0.0164

The average will display the 'central' value between all three test results of each section. And the standard deviation will display the quantity of dispersion between each of the three test result values. These two calculations will be very useful if identifying the most efficient structure for the Neural Network.

The results of the average are in direct correlation with the results of the standard deviation, and therefore there will be minimal anomalies. The lowest average was LR.3 & H5 with 0.1028, and the lowest standard deviation was also LR3. & H5 with 0.0051. There was also another set of values that were very close to this; LR.7 & H5 had an average of 0.0052 and standard deviation of 0.1031. These setups were the most efficient due to their consistently, however by ruling out a single value, they did not have the lowest value from all the results. In fact, the lowest single testing value was 0.0842 from LR.5 & H6; however, it had a significantly higher standard deviation of 0.0164, and average of 0.1110.

I can therefore conclude that the most efficient structure for a neural network is; a 'Learning Rate' of 0.3 and 5 'Hidden Nodes'. This is because it consistently produces low testing values, and it is essential that the Neural Network consistently produces test results that are similar to its training.

3 AI in Games

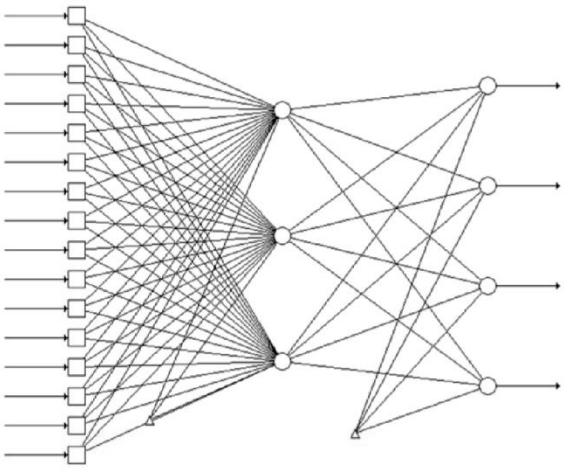
Report: Neuro-Evolution

3.1 Introduction

Neuro-evolution is a machine learning technique that applies to evolutionary algorithms which use neural networks to focus on developing and improving itself. It is particularly applied to artificial intelligence in autonomous robotics and video games. Neuro-evolution takes it inspiration from nervous systems and biological evolution, as it focuses on the genetic changes in a population that is inherited throughout several generations. This machine learning technique is particularly useful, due to that it can be applied more extensively than a generic 'supervised learning algorithm' which requires a specific form of input in order to learn, and thus produce results. This also means that neuro-evolution is capable of learning without 'explicit targets', and therefore it is a very effective approach to solving 'reinforcement learning' problems (learning by interacting with an environment).

3.2 Neural Networks in Neuro-Evolution

Figure 1



An artificial neural network is represented as networks containing interconnected nodes, which is capable of calculating values based on external inputs provided to the network. The behaviour of this is generally determined by the architecture of the neural network and the strength between its nodes. For instance, the neural network displayed in figure 1 is a screenshot taken in the program "Multiple Back-Propagation (MBP) Version 2.2.4" with the number of nodes being 16-3-4. This neural may behave differently to a neural network with the nodes 16-2-4.

The nodes of a neural network all contain a different purpose; there is: an input layer, hidden layer, and output layer. The input layer contains units that receives input from an external source, which will be used to train. The hidden layer contains units that are capable of transferring the input into information that can be used in some form or another. And the output layer contains units that respond to the information gained on how to complete a certain task. A neural network is required to be trained in order to learn and develop; and thus, requires an external source of data. For neuro-evolution to work efficiently, the neural network must be supplied with an evolutionary algorithm, which uses aspects inspired by biological evolution. This could be based on: reproduction, mutation, recombination or natural selection; however, one of the strongest aspects is genetic representation of the neural network, that is manipulated by the 'combination' and 'mutation' operators.

3.3 Uses of Neuro-Evolution

Neuro-evolution is an existing factor in video games and is mainly used to enhance the behaviour of agents within the game, therefore making it more challenging for the player to competing against these agents. However; the most dominant opportunity for neuro-evolution in games is adding an extension to an already existing video game, as opposed to releasing a game with agents containing integrated neural networks. This is due to the reason that it may create unreliable outcomes for each agent, as well as a reduced frame-rate for the player. If each agent was given a neural network, the computer (or relevant device) would be required to calculate the output of each action and thus requires more processing power.

Within these types of games, the player will explicitly train game agents to perform various tasks; the agents will learn and be capable of figuring out how to solve difficult challenges in the video game. For instance, the game “Galactic Arms Race” is space shooter in which players pilot a gunship where the main objective is to defeat any other gunships within the area. The game is fitted with neuro-evolution mechanics to evolve the weapons of the gunship and become a more powerful opponent.

Figure 2

3.4 Conclusion

Neuro-evolution is an auspicious new technology that will be extremely beneficial to video game applications; however, it is yet to be fully developed and contains multiple difficulties in its current state. The technology is an exciting frontier in artificial intelligence, due to the capabilities that it contains. By developing neuro-evolution, we will soon be able to produce applications that are capable of learning quickly and applying that knowledge in specific and problematic situations.

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4 Autonomous Mobile Robotics

Report: Robot Teleoperation and 3D Perception

4.1 Introduction

The goal of this project, was to create a simulation of a robot that is capable of moving and rendering a three-dimensional map of its environment. I have used the programmes “V-REP” and “RVIZ” for this project, on the “Linux Ubuntu” operation system. The robot would move by the means of ‘teleoperation’.

4.2 Development of Teleoperation

Initially, the robot was incapable of moving, as the individual ‘parts’ had not been recognised in the program. To fix this, the separate parts needed to be identified and initialised in the code for the robot found in “Pioneer_p3dx”. This will allow the program to understand which parts the robot is connect to, and thus understand how the robot may move around the terrain. By declaring each part, they also need to be identified as a ‘Parent’ or ‘Child’ in the program. In order to achieve this; the code needed to be written:

```
simExtROS_enableSubscriber()
```

This function was written for each part, and subscribes each part to a specific message, therefore allowing each part to be given a specific name. This was done for each child part, and every part was connected to their parent parts. These parts were labelled on the 3D model of the robot in RVIZ. There was also a need to add some form of velocity when the user inputs one of the arrows on their keyboard. This was done by using the function ‘simSetJoinTargetVeclocity’. This was done for the left and right motors of the robot.

```
simSetJointTargetVelocity(motorLeft,vLeft)
simSetJointTargetVelocity(motorRight,vRight)
```

In order for the robot to move with user input, a separate script had to be implemented; however, before doing this, I was required to create new directories for this specific task. I used to terminal to navigate the directories, subsequently created a new directory named “pioneer_keyboard_teleop” alongside a file named “script”. This is the directory that contains the script specifically designated for the robot to be able to register user input. I was then required to make the file executable, and therefore I performed this by typing “chmod +x pioneer_teleop_key” and “ls” into the terminal.

Once I had completed this, the user would be able to control the robot with the arrow keys; however, firstly I needed to start the graphical user interface of ROS that allows the user to visualise the robot in ROS. In order to perform this, the following code was inputted into the terminal:

```
roslaunch aint153pp_robot_launchers vrep_rviz.launch
```

Once this was done, I would use another terminal to navigate to the “aint153pp_ws” directory and input:

```
source devel/setup.bash
rosrun pioneer_keyboard_teleop pioneer_teleop_key
```

This code would create a new tab labelled as “Keyboard TeleOp”. In order for the robot to move, the user was required to have clicked on this panel, as it was responsible for running the script.

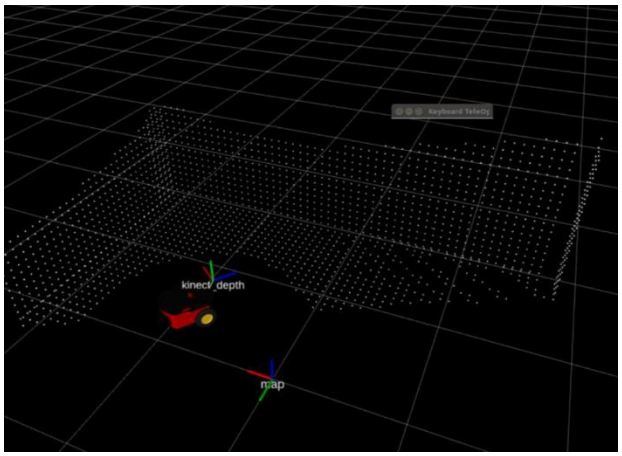
4.3 Development of 3D Perception

After undertaking the procedures for teleoperation, I was then required to allow the robot to perceive its environment, and render it using “Point Clouds”. Firstly, I created a new component, by adding the “Kinect” to the robot’s parts. I later added various lines of code to the script of the robot that will enable ROS to retrieve from VREP, the images of the Kinect sensors and its position relation between the sensor and the robot.

```
kinect_rgb=simGetObjectHandle(“kinect_rgb”)
kinect_depth=simGetObjectHandle(“kinect_depth”)
simExtROS_enablePublisher('/tf', 1,
simros_strmcmd_get_transform, kinect_rgb, base_link,
'kinect_rgb')
simExtROS_enablePublisher('/tf', 1,
simros_strmcmd_get_transform, kinect_depth, base_link,
'kinect_depth')
simExtROS_enablePublisher("/rgb/image_rect_color",1,simros_str
mcmd_get_vision_sensor_image,kinect_rgb, -1, "")
simExtROS_enablePublisher("/rgb/camera_info",1,simros_strmcmd_
get_vision_sensor_info,kinect_rgb, -1, "")
simExtROS_enablePublisher("/depth/pcd",1,simros_strmcmd_get_de
pth_sensor_data,kinect_depth, -1, "")
```

After adding these lines of code, ROS would now display reference frames of the Kinect. The Kinect would retrieve information, however it needed to be presented in 3D format. This was achieved by going into RVIZ and adding 'PointCloud2'. Unfortunately, the information that the robot would gather is local, as it will only create a 3D scan of the world that is detected in RVIZ. The scan has not be integrated with a 'global' representation of the world. In order to fix this issue, I was then required to extend the main script of the robot, to include an additional transformation. This would refer to both a global and local reference frame. In the aftermath I created the file "mapping.launch" within the directory '*aint153pp_ws/src/aint153_robot_launchers/launchers',* which contained the following code:

```
<?xml version="1.0" encoding="utf-8"?>
<launch>
<node name="mapping" pkg="octomap_server" type="octomap_server_node" respawn="false" output="screen">
<param name = "base_frame_id" value = "/kinect_depth"/>
<param name = "resolution" value = "0.075"/>
<param name = "sensor_model/hit" value = "0.75"/>
<param name = "sensor_model/miss" value = "0.45" />
<param name = "sensor_model/min" value = "0.12" />
<param name = "sensor_model/max" value = "0.98" />
<remap from = "cloud_in" to = "/depth/pcd"/>
<remap from = "octomap_point_cloud_centers" to = "/3d_map"/>
</node>
</launch>
```



After this was complete, the program would now generate a 3D map of the environment in RVIZ that the Kinect sensor detects.

5 Introduction to Intelligence

Report: Artificial Intelligence

5.1 What is Intelligence

5. "Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience." Common statement with 52 expert signatories [13]

There is no single definition for the term 'Artificial Intelligence', as it is still in development and is yet to be fully understood. As a result; everyone will have their own opinion on what it is and thus only accepts specific meanings or definitions of the term. I believe that the definition for intelligence is well executed in the "Mainstream science on intelligence: An editorial with 52 signatories, history, and bibliography", as it states multiple factors that are key in creating an artificial intelligence system. It states that it must contain the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, and learn quickly from experience. These are all valid points and are required to be implemented into a system in order for it to be labelled as 'intelligent'.

One strong keyword used, is the term "learn"; as a system will be capable of learning from previous experience. However; would the system still be considered intelligent if it were incapable of applying that knowledge to comprehend complex ideas or scenarios, and solve related problems? As an intelligent system, it should be able to acquire knowledge from study, experience or being taught, and be capable of applying it.

There are multiple ways of measuring intelligence; however, these methods often limited to a very specific type. For instance; the 'IQ Test' is often seen as a liable method for measuring intelligence, but only calculates a figure that signifies how much information a human is capable of remembering. It lacks the capability of measuring other types of intelligence, such as emotional intelligence. An intelligent system must be implemented to think similarly to a human, as opposed to logically. This is because logically thinking will not be able to distinguish the difference between right and wrong behaviour.

5.2 Applications of Use

Alzheimer's is a progressive mental deterioration that can occur when at middle or old age, due to the degeneration of the brain. As this disease is related to the functions of the brain; it will fail to show clear symptoms of an early stage of Alzheimer's disease. Fortunately, an artificial intelligence system has been created to identify changes in the brains of people that are likely to get Alzheimer's in the future. This application of artificial will be extremely useful for medical purposes, as patients will be able to be treated early, therefore reducing the chances of it developing to a critical stage.

One aspect in which I believe artificial intelligence should be banned is: weapons, in particular; robots and drones that are capable of harming an organism or human. This is due to the potential risks that occur when these systems are available for use by certain organisations.

For instance; the miniaturised drone “Slaughterbots” is a concept that uses facial recognition to identify its target, and then will proceed to administer a small yet lethal explosive blast to the victim’s skull. This appears to be a very effective solution to specific issues, such as terrorism. They are still in development; however, it is debatable for whether these weapons should exist, due to the vulnerabilities that every computer system contains. Regardless of how advanced the artificial intelligence is within these small devices, there is still the possibility that they can be hacked and manipulated from an enemy organisation. If this were to happen, it can potentially cause a large amount of danger to citizens. It may also be considered inhumane for this type of weapon to be used on other people, regardless of the criminal status.

5.3 Will AI and robots take our jobs?

A large amount of people are somewhat concerned about the possibility that, when robots evolve to perform specific tasks; if they’ll replace humans in their jobs. In order for this to occur, artificial intelligence also needs to evolve; as currently it is challenging for robots to perform even the simplest tasks. A robot would be created to perform a very specific task, which will consume a lot of time and resources to develop.

A robot may function at a far more efficient rate than a human, as people are prone to making mistakes, whilst robots will function according to their code. For instance; the AI ‘Libratus’ beat pro poker players, but was not thinking like a human. It was calculating the chances of losing per hand, and planned based on the answer. This means that robots would be far more effective in manual labour, such as manufacturing. However; there are jobs that nobody would necessary enjoy having, and thus robots would be beneficial for these scenarios. For instance, there would be significantly less casualties in war, if robots were responsible for performing the jobs that are dangerous.

There are multiple jobs that robots would be incapable of undertaking, as it required the intellect of a person, such as customer services. However; if we reach such a technological stage, a large portion of the economy would be incapable of having simple jobs, such as cleaning. A new system would have to be in place in order for people to earn their salary. There would also be new opportunities for jobs if robots were heavily used; in particular maintenance. This would create new jobs in replacement of the ones that have been lost but would specifically relate on computing tasks.

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