Coursework Portfolio

AINT153PP Intelligent Systems

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2017

Table of Content

Contents

1 Introduction to Intelligence

Abstract
My opinions on intelligence and what it means.

1.1 Introduction
In this section, I will discuss my thoughts on some important questions on intelligence such as what my definition of intelligence is, where I would like to see AI used and how I think AI will affect the job market.

1.2 What is your definition of intelligence?
In order to best describe what intelligence is, I have chosen a quote from the Random House Unabridged Dictionary, 2006, which is that intelligence is the "Capacity for learning, reasoning, understanding, and similar forms of mental activity; aptitude in grasping truths, relationships, facts, meanings, etc."

There are many reasons I have picked this definition and the first one lies in the word 'understanding' that is used. In my opinion there is a vast difference between receiving information and understanding it. We can tell a computer to do something and it will do it, maybe even learn how to do it more efficiently, however it would only truly be intelligent if it understood why it was doing it and the principles behind its reasoning. Another aspect of this definition that I feel represents intelligence is when intelligence is defined as having an "aptitude in grasping truths, relationships, meanings". This relates once again to understanding. I believe being able to make connections between abstract concepts and build upon one's own knowledge via these connections is a sign of true intelligence and that without this ability to comprehend information to form ideas or find solutions, then the agent is not intelligent. Another key word in this definition is capacity – the capacity to learn more is key when it comes to intelligence. An idea or problem might be presented to an agent, that it may be able to understand/solve however to be intelligent, it needs to have the capacity to learn more than just that one scenario. Without that capacity, the agent is only able to process a single situation and cannot be defined as intelligent. For these reasons I believe the extract from this dictionary suit my definition of intelligence very well.

1.3 Where would you like/dislike to see AI used?
Artificial intelligence has many useful applications throughout the world in many different aspects of society. One aspect of society I believe artificial intelligence could be used for is in leisure centres. As a lifeguard myself I have spent time thinking about how intelligent systems could be used in the aid and protection of people swimming, as well as how to utilise the same system to allow customers to have an efficient experience at the centre.

Using bands similar to fitbits that monitor heart rate and similar measurements an AI system would be able to create a profile for the individual wearing the band. If the band transmits any readings that fall outside of this profile such as unusual heartbeat, then the AI could alert the lifeguard by playing a sound and even potentially deploying a floating implement to keep anyone in danger afloat. In addition, the band could have an input to sound an alarm if a customer needed to call for help. The same system could also be used as a health monitor for customers by tracking lengths completed, speed of swimming etc. These measurements would add to the customer profile and suggest swimming workouts and goals that change and progress over time.

Outside of the swimming pool, this profile would track workouts in the gym or activities in a sports hall. All of these measurements would add to the profile once again and the AI could determine new workouts for the customer. By linking the bands to cardio machines, the customer profile could seamlessly integrate into these systems and allow for personalised workouts the moment the customer stepped onto the machine without having to input anything manually.

Overall, I feel this kind of artificial intelligence system would create a more efficient, personalised experience in leisure/fitness centres globally and could potentially save lives with its lifeguard alert system.

1.4 Will AI and robots take our jobs? Which ones? Would this be only bad?

The Libratus artificial intelligence victory over four professional poker players was an astounding milestone in AI technology. The ability to use strategic reasoning with imperfect information was vital in its success and has the capacity to carry over into many real-world applications. The IEEE Spectrum article discusses how the technology could be used in business negotiations, finance or even military technology.

With this potential in the technology, the question of the job security of humans against the competition of AI is an important one. I feel like the role of AI and robots will definitely increase in the work place. Sectors such as finance and business will be able to make great use out of these systems as there is a lot of imperfect information involved. One example is the stock market where an AI who could use strategic reasoning to predicts market growth would be far more useful than a human counterpart. In these sectors, the use of AI would be beneficial to society however there are some sectors where AI will not or should not be used and jobs will remain with humanity. One of these sectors is the justice system. An AI system may be able to examine evidence and put together a profile on someone, however judgement on court cases requires human judgement that so far has not been replicated in AI.

Overall, I believe artificial intelligence will take many jobs in the business sector and areas where decisions made on imperfect information is crucial. This use of AI will be beneficial to society and will improve efficiency wherever they are implemented. However, I also believe there will be many areas that AI will simply not be able to infiltrate as they require human emotion and connection.

2 Test-Driven Development and Reinforcement Learning

Abstract
A report on the test-driven development and reinforcement learning including the methods involved and its applications in the world.

2.1 Introduction
This report will discuss the domain applications, models and methods of both Test-Driven Development, TDD, and Reinforcement Learning. Test-Driven Development is a software development procedure that utilises very short development cycles in order to produce functional, succinct code through the use of small tests as well as being able to quickly catch any bugs that may be present. Reinforcement learning is a method of machine learning that uses interaction within an environment and a consequential reward system based on these interactions to reinforce positive actions carried out by the agent. Through these positive rewards, the agent learns better approaches to the current problem it faces.

2.2 Models and Methods
Test-Driven Development
Test-Driven Development uses a very short development cycle that requires the user to write tests for the code before the functional code is ever written – this test must initially fail. Once the test is implemented, code is written to pass the test and any previous tests as well. Once this code passes, another test is written for the next section of the program that once again will fail because the code necessary to succeed hasn't been written yet.

The method of the Test-Driven Development is to run these tests often so that feedback is quick, and bugs can be rooted out efficiently as the program is built. The unit of code being tested must remain small as well for added speed and efficiency. Each induvial aspect of source code will have its own independent tests. These tests are written in code as well and are accessible at any point in the development process to evaluate the program's current state. By reviewing these tests and ensuring they are passed, an application can be built section by section with the knowledge that all bugs have been found and the program does what it is intended to do.

Reinforcement Learning
Reinforced learning is a type of semi-supervised learning. Regarding machine learning, this means that as the agent interacts with its environment it is given rewards based on its actions. Reinforced Learning relies on actions, states and rewards. The agent has an initial state, and then it will carry out an action from a set of actions it has the potential to carry out. Based on this action and how it affects the environment, the agent will either be rewarded or punished, and its current state will be updated. For example, if the agent is a video game character then its initial state is the start of the level, and the end of the level will be its goal state. If the agent takes a step towards the end goal, then it will be rewarded positively as it has taken a step further to the goal state. However, if the agent were to make an action that results in the death of the character this would be a negative action and would be punished so the agent learns that repeating the action in that situation would result in a negative result.

One reinforced learning technique is Q-Learning. As the agent navigates its environment, it will learn via the reward system which actions take it closer to the goal state and which ones slow down or stop the process entirely. It will develop a policy, π, that is not environment specific which maps states to certain actions. As the agent receives new rewards each state or state/action pair is assigned a value with the more positive states having higher values.

This navigation is composed of episodes, trials and an experiment. An episode, or rollout, is a single attempt of the agent trying to navigate from the initial state to the goal state. A trial is composed of many episodes during which the policy is optimised; all of the episodes within the trial share the same policy. An experiment uses several trials to assess the overall learning performance. Throughout the experiment, each trial uses a new empty policy to adapt and improve.

The algorithm for Q-learning is:

$$Q(s,a) \leftarrow Q(s,a) + \alpha \left[r + \gamma \max_{a'} Q(s',a') - Q(s,a) \right]$$

Where the state = s, action = a, reward = r, new state = s', γ = discount factor, α = learning rate.

At the start of a trial the Q-table, (Q(s, a),) is initialised, and then an action is taken. Once the action is completed, the reward is measured, and the Q-table is updated. The learning rate is the rate at which old information is overridden by new information that the agent has learned.

As the experiment takes place and the agent undergoes the reinforced learning, there is a balance between exploration vs exploitation that must be considered. If the agent only selects the highest value actions, then it may get stuck quickly. By allowing the agent to explore lesser value actions it may in turn find better ways of progressing towards the goal state. However, once an optimal solution to achieving the goal state is found, then the exploration may hinder finding the best solution. Typically, the exploration an agent will undergo will decrease gradually throughout the trial.

2.3 Domain Application

Test-Driven Development

Test-Driven Development is used by many companies and developers as the process allows for clean and efficient coding. TDD is also utilised in agile development frameworks such as extreme programming. This is a type of programming that favours quick and short development cycles to better review and optimise code to customer requirements. Due to the fast nature of the development cycles used in TDD, the process fits in with this rapid but controlled approach to creating software.

Reinforced Learning

There are many applications of reinforced learning within the field of artificial intelligence. One famous example is the AlphaGo system which used reinforcement learning alongside other methods to challenge and defeat professional players in the complex game of Go. Reinforcement learning also has more practical uses such as being utilised in the robotics, industrial automation, dialogue systems such as chatbots, medicine and finance. All of these areas are seeing an increased use of this type of machine learning to optimised performance and exploring new efficient methods to utilise.

2.4 Conclusion

To conclude, Test-Driven Development is an extremely beneficial method of coding when it comes to understanding what direction you are coding software, quickly rooting out bugs and cleaning up code efficiently. The short development cycles allow for fast feedback on code and tests ensure everything is working the way it should be.

In addition, reinforcement learning allows systems to progressively optimise a solution/path to an environment via its reward system. By placing values on certain states or actions and utilising them to find efficient results, this method can be used in many real-world applications to streamline operations in many different aspects of society. I believe reinforcement learning will continue to grow and its use in society will increase, letting businesses and research develop further than they possibly could before.

3 Autonomous Mobile Robotics

3.1 Introduction

Autonomous Mobile Robotics is a growing and extremely beneficial application of artificial intelligence that is being used today and this report will discuss what exactly this branch of robotics is, how the technology is applied in the real world and what models and methods may be used in the development of these systems. To start with, lets look at each section of this title:

Autonomous: Denoting or performed by a device capable of operating without direct human control. [1]

Mobile: Able to move or be moved freely or easily. [2]

Robotics: The branch of technology that deals with the design, construction, operation, and application of robots. [3]

By looking at these definitions, it is understood that Autonomous Mobile Robotics is the use of artificial intelligence within robots so that they can move around and interact with the world freely and without human control. The main application this report will focus on is the use of autonomous mobile robotics in disaster situations to access areas that present to much of a risk for humans to enter.

3.2 Domain Application

The use of these autonomous robots varies throughout the world due to the extensive possibilities that these systems can be utilised for. The ability to send a robot into a situation instead of a human can be extremely beneficial. Some of these situations that this domain of autonomy may be applied to is planetary exploration such as the robots on Mars, or underwater exploration. Essentially these machines can be used to explore and gather information in areas where it isn't possible for mankind to reach or where it's just more efficient to send a robot. The main application of these robots however is in disaster environments. In these extreme scenarios, it is not possible to send in human reconnaissance or aid due to the danger that is presented such as collapsed roofing or unstable structures. In these instances, it is necessary to send in a robot that is able to enter and scan the area for damages. Some examples of these are the Unmanned Remote Sensing and Sampling (URSAS) which is used in disaster situations to 'to sample radioactive plumes and measure ground-based radioactive emissions' [4] or the UAV/UGVs used by a company called NIFTi in disaster situations that this module and report focuses on. One example of these NIFTi autonomous vehicles being deployed was when earthquakes hit Mirandola, Italy and the ground robots and multicopters 'gathered 3D reconstructions ("maps") and high-resolution video material about structural damage to ceilings, arches, and aisles in these (largely destroyed) buildings'[5]. Two firefighters had been killed in Mirandola by a collapsing roof [6] which demonstrates what kind of situation these autonomous robots are necessary for. By using the aid of these self-driving vehicles that are able to map and scan an area, the risk of more fatalities decreases significantly.

3.3 Models and Methods

There are many different models and methods used throughout the field of Autonomous Mobile Robotics and in the NIFTi autonomous. Some of these methods help control the robot's movement whereas others are focused on scanning the area for information and mapping. The ROS and V-REP systems that will be discussed further on help create the complex behaviours that are required in these robots.

For any of these models to be autonomous they need to utilise reactive behaviour. This is a process of sensing the environment and acting accordingly. For example, a robot may detect a pile of impassable rubble close by, it then needs to make the decision to move away from this obstacle and carry out that action. Using dynamic obstacle detection and path planning, these robots are able to navigate extremely difficult terrain. These methods of detection provide feedback to the robot, so it knows its own position and an adequate path to move along. To enable the robot to carry out this path planning, a 3D laser scanner is equipped to the machine. This scanner can create a map of points of the area, a point cloud, which can then be built upon to find areas of that are easily traversable and a minimal cost path for the robot to take.

Furthermore, a method that is used with the NIFTi robots is the use of the RCAMP system. This is the Resilient Communication-Aware Motion Planner for mobile robots with autonomous repair of wireless connectivity. This is a system that 'that takes both connectivity and the goal position into account when driving to a connection-safe position in the event of a communication loss'[7]. This kind of system is necessary for these robots due to the unpredictability of disaster scenarios where the failure of hardware and the loss of connection could impact the robot's mission.

The robotic vehicles require quite complex autonomous systems in order to operate functionally. The construction of these systems is carried out via robot simulators which can be used as frameworks to write the software necessary for the robots. In this module, the ROS and V-REP programs were used. V-REP is a robot simulator that contains a development environment that can be used to write robot controllers, algorithms and prototype the robot. In addition, ROS stands for Robot Operating System that is used to streamline the creation of robotic behaviour. ROS also allows for a collaborative experience that enables different areas of expertise to connect and employ each other's research to further extend the capabilities of their own robotics.

3.4 Conclusion

In conclusion, the field of autonomous mobile robotics is one of complex systems and also one of necessity. These machines enable us to safely scout out hazardous terrain and create accurate models of dangerous areas that we would otherwise be incapable of ascertaining due to the risks of entering these environments. The systems and programs used to develop these robots is streamlined and allow for helpful collaboration between experts that furthers this field's capability. I believe this area of robotics is extremely beneficial to humanity and has the potential to save many lives and make new discoveries in areas that would be inaccessible to humans.

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4 Big Data

Word Count: 990

4.1 Introduction

As a teacher, tracking how an individual student is progressing amongst a class of 20+ students can be difficult. Moreover, giving feedback to students can take time due to the amount of marking the teacher has to undertake, and the quality of this feedback can vary wildly from teacher to teacher. These pitfalls in education can lead to some children missing out on essential attention and education that would otherwise help them grow as both a student, and a person. The aim of this essay is to address how the use of Big Data is currently be used in the educational system to aid teachers and students, to contemplate the challenges this method of data mining faces, and the potential the technology contains that could be used to change and direct education towards a better future.

4.2 Current Applications

The educational system relies heavily on formative assessments and feedback for students, so they can learn from their mistakes to do better in the next assessment. However, as previously mentioned, feedback for students can be slow, uninformative or overlooked in schools. The use of Big Data to track students has already been implemented in some areas of the world to aid and improve this system and as West, D.M. (2012) states, this is because 'Data mining and data analytic software can provide immediate feedback to students and teachers about academic performance. That approach can analyse underlying patterns in order to predict student outcomes such as dropping out, needing extra help, or being capable of more demanding assignments.' True to this, several schools and universities have implemented this kind of data tracking to monitor student progress. For example, as found in Picciano A.G. (2012), 'Purdue University's Course Signals application detects early warning signs and provides intervention to students who may not be performing to the best of their abilities before they reach a critical point'. These warning signs are compiled from data such as attendance, grades, and the feedback the students receive.

Another method of tracking data and monitoring students is through developing dashboards. Dashboards collect key measurements in an easy to interpret interface in order for school officials to quickly and visually see how the school is doing. One such dashboard is DreamBox, a dashboard for administrators that collects data. This is explained in West, D.M. (2012) as the DreamBox 'summarizes proficiency data for each grade level in particular schools. It shows what percentage of students in the first grade have completed a concept mastery, what percent are in progress, and what percent have not started mastery exercises.' By doing this, the students' performance can be tracked and compared by the administrators for each grade.

4.3 Challenges

Whilst these methods of data collection can prove useful within education, there are still barriers and challenges that face this next step in education. One of these challenges is the need for data sharing systems – many institutions will have separate systems for tracking a student's attendance, grades, disciplinary action and unless they are connected, a full picture cannot be compiled to accurately track the student. In a report by the U.S Department of Education (2012), its proposed that to successfully install Big Data into higher education would depend on collaborative initiatives between various departments within an institution.

In addition, the data tracked must be easy to track and able to be compared analytically. This is pointed out in West, D.M. (2012) 'Information entered into data systems must be easily understood and coded in comparable ways. Working on common semantics and metrics will allow system administrators to aggregate material and analyse the information.' If the data is to be analysed across schools to record students in a certain geographical area, then the input data must be universal and comparable. Daniel, B. (2015) supports this view and the need for shared systems by writing that this obstacle is eminent 'where data comes in both structured and unstructured formats and needed to be integrated from disparate sources most of which are stored in systems managed by different departments'.

4.4 What lies ahead?

With these challenges in mind, the big question is what is the future of Big Data in education? As the technology develops to become more accessible, the evolution of education seems to be leaning towards this mass tracking of student data to provide instantaneous feedback and student profiles to aid administrators and teachers. Dede, C.J. (2016) believes 'The next step is to accelerate advances in every aspect of education-related data science so we can transform our ability to rapidly process and understand increasingly large, heterogeneous, and noisy data sets related to learning.' If separate departments within and across institutions could come together and collaborate then it may be possible to create an analytical system using Big Data that allows for an accurate and predictive support system for students that allows them to have a richer education that is tailored to each individual student. This kind of system would ensure no student would be overlooked and would receive all the guidance and challenge they required to thrive in the educational system. To create the foundations for these kinds of collaborations, new organisations and policies would need to be put in place to 'specify who is accountable for various portions or aspects of institutional data and information, including its accuracy, accessibility, consistency, completeness and maintenance' Daniel, B. (2015).

4.5 Conclusion

With the discussed analytical systems already in place in educational institutions alongside many more examples across the world, the future of Big Data's involvement in the education system seems to be one of growth and development. These implementations of mass student tracking pave the way for more streamlined, accessible and accurate systems that will provide support systems and personalised learning for students. Although, as mentioned, this future relies on the ability of to collaborate to construct comparable data that is accessible and easy to understand. I believe this kind of collaboration will be possible and that Big Data will become a centre piece in the future of education.

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