The Future of Robotics

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Abstract:

This thesis aimed to consider the future of robotics in society and in particular, within educational curricula. The writer summarized the current role of robots in industry and surveyed a small number of social peers to gain an insight into current attitudes and perceptions of robots in society, particularly concerning employment security. The outcome of this survey showed that people are not particularly concerned about their own employment security although they exhibit greater concern for future generations. The limits of this survey must be considered in that it was conducted on a small group of connections of the author using social media meaning that the group size was too small to be significantly meaningful whilst also meaning that those surveyed belonged to a narrow social demographic.

The author also conducted a trail using a readily available robot remote-control car kit. The kit was found to be educational and suitable for a UAS student to learn the basics of robotics while being flexible enough to accommodate deeper study for motivated students. However, the author noted that since educational institutions are now beginning education in robotics at a young age, a kit of this nature will cease to be useful for higher education students in the near future and more advanced educational opportunities will be needed to support the development of future students.

The author finds that the development of robotics and robots is unlikely to regress or slow down and therefore educational institutions must work with their students to ensure that they are ready for the evolving job market.

Keywords:	Robots; Robotics; Education; Artifical Intelligence
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CONTENTS

1 INTRODUCTION

Robotics is a rapidly developing field and as such, there are increasing concerns about the rate at which it is developing and the implications of increasingly intelligent robots in society.

This thesis will cover a brief history of robots as well as an overview of their current status. Real-world examples of the functions of robots will be detailed and their operation explained in terms of both software and hardware.

The primary aim of the thesis is to make predictions for the future of robotics and in order to do this, it is necessary to consider the limitations of the technology both physically and from an ethical standpoint.

This thesis will also serve to provide a review and recommendation of commercially available robotics kits for use within Arcada.

For the purpose of clarity, it is important to first establish definitions of the following terms, as they will be used frequently throughout this thesis:

- **Robotics**

  Robotics is the branch of technology that deals with the design and construction of robots.

- **Robots**

  A robot is a machine that can be programmed to carry out tasks. A robot can be autonomous or non-autonomous, intelligent or non-intelligent.

- **Artificial Intelligence (AI)**

  Artificial Intelligence (AI) is the branch of computer science that is used to programme robots. AI serves to mimic human intelligence to some degree.

- **Artificially Intelligent Robots**

  The term ‘robot’ alone does not necessarily signify an artificially intelligent machine. A robot that is programmed to carry out a repetitive task is a robot but is not an artificially intelligent robot. An artificially intelligent robot is a machine that has been programmed to carry out complex tasks and make decisions in a way that mimics human intelligence.

(Owen-Hill, 2017)

2 LITERATURE REVIEW

2.1 History of Robots

Culturally speaking, the concept of artificial intelligence is not a modern one. A quick dive into ancient mythology will demonstrate this with tales such as *Pygmalion and the Image* wherein Pygmalion's sculpted creation of his ideal woman came to life (Hawthorne, et al., 2018) and the stories of *Hephasteus*, the Greek God of fire, a blacksmith and craftsman who dabbled in artificial intelligence with creations such as golden guard dogs for his palaces and a giant bronze man to protect Crete (Greek Mythology, 2019). However, for the purpose of this thesis, the focus will be on the modern interpretation of artificial intelligence, namely the science of robotics and the function of robots.

The word 'robot' was coined by Czech playwright Karel Čapek in his play 'R.U.R. – Rossum's Universal Robots', published in 1920. The word is derived from the Czech word for 'forced labour' and in the play, the robots in question were chemically synthesized human-like beings. Through continuous modification to make them more like humans, the robots operated far more efficiently than their human counterparts, resulting in their eventual domination of the species they were designed to serve. This theme can be seen throughout pop culture through to the present day with works such as *Terminator and Stepford Wives.*
(Encyclopaedia Britannica, 2019)

Twenty years later, the word 'robotics' appears in the works of Isaac Asimov, a Russian-born American author and biochemist best known for his career as a science-fiction writer. Asimov's work will be reviewed in more detail in 4.3.1., as he outlined a well-known series of rules for governing robots in his *Robot* series of books. (Gregersen, 2019)

These are not merely fun facts. It is important to mention this as current attitudes toward robots will be analysed in chapter 4.1. and as such, it is prudent to give some consideration to the possible influences of popular culture.

Practically speaking, the first industrial robot – the Unimate – was created in 1959 by American inventor George Devol and Joseph Engelberger, often referred to as the 'Father of Robotics'. The Unimate was a robot arm designed for use in tasks that were dangerous or unpleasant to humans. The timeline below gives a brief overview of the creation and implementation of this invention.

1954 – Unimate was invented

1959 – Unimate #001 was installed on the assembly line of GM

1961 – Unimate 1900 became the first mass-produced robot arm

1966 – Unimate was shown on television for the first time in a live broad cast of *The Tonight Show*, where the arm performed a number of crowd-pleasing tasks including pouring a beer

– Nokia of Finland was licensed to manufacture the Unimate for Scandinavia and Eastern Europe

1969 – Kawasaki Heavy Industries (now Kawasaki Robotics) was li censed to manufacture the Unimate for the Asian market

– Unimate was implemented for spot welding by GM, increasing the output of the assembly line to double that of any other plant

(Robotic Industries Association, 2019)

2.2 Ethical Concerns

The question of ethics is often raised in relation to robots. According to innovation platform for AI & Robotics, Kambria, the following are the seven most pressing ethical concerns in artificial intelligence.

1. Job loss and wealth inequality.
2. Possibility of AI making a mistake.
3. Should AI systems be allowed to kill?
4. Rogue AI.
5. Singularity and keeping control over AI.
6. How should we treat AI?
7. AI bias.

(Kambria, 2019)

The issues surrounding AI systems are complex and there is no one correct answer, although there are ongoing attempts to tackle these questions. In this chapter, Isaac Asimov's widely known 'Three Laws of Robotics' will be briefly reviewed.

2.2.1 Isaac Aminov's 'Three Laws of Robotics'

When considering the governing principles of robotics, it is important to mention the most well-known set of laws that have been seemingly laid down as a starting point for the regulation of AI.

Isaac Aminov was a science-fiction writer who has authored the 'Three Laws of Robotics' with the fourth law, known as the 'Zeroth Law' added later. They are as follows:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.
4. A robot may not harm humanity, or, by inaction, allow humanity to come to harm.

   (Singer, 2009)

While these laws are popular and well-known, experts say they are dated and much too vague for the sophisticated artificial intelligence capabilities of today's world.

According to Ben Goertzel, an AI theorist, the robots that Isaac Asimov imagined will soon be a reality, and it was his consideration that robots would reach human-like capabilities at best. However, Goertzel believes that superhuman AI and robots will be possible before long and for this reason, the laws of robotics are inadequate for the task of governing robots. (Dvorsky, 2014)

Further, Louie Helm, another AI theorist, goes on to say that the laws are widely known but that the industry consensus is that they are not an adequate starting point, as they are based on deontology which is considered by philosophers to be a flawed ethical framework. As such, Asimov's laws are not being used to guide or inform AI safety researchers in any real-world setting. (Dvorsky, 2014)

Given the above, there is no practical use in delving further into the work of Isaac Asimov in the context of this thesis.

2.2.2 The Famous Trolley Problem

A simplistic argument would be that robots should not allow a human being to come to harm however, this does not consider the situation where any action or inaction would result in at least one human coming to some harm. Such situations are common and cannot be easily defined, nor is it a simple task to clearly define what constitutes harm, as harm comes in many forms. It may seem that the logical next step is to consider programming robots in such a way that their actions or inaction result in the least harm to humans. A popular way of illustrating this dilemma is the 'trolley problem', below.

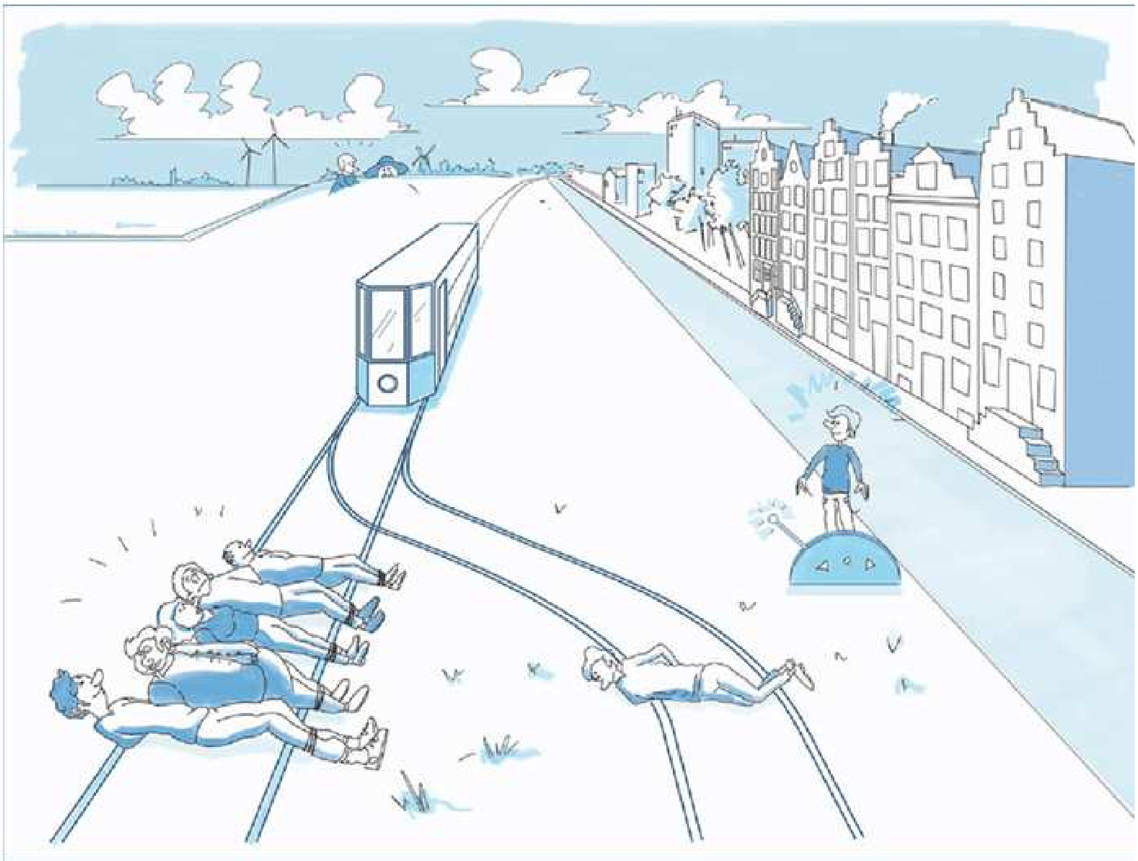

Figure 1 Illustration of the famous 'trolley problem'. (Kormelink, 2019)

As can be seen in the image, the oncoming train must choose one of two tracks. One choice will result in killing one person, while the other will result in killing five. What makes trolley problems so compelling to discuss is that human lives cannot simply be reduced to simple math. Even if one is to accept that quantity does not trump quality, how can the criteria by which quality is determined be defined? This is a question far larger than the scope of this thesis and the aim is not to answer this – but to call attention to the complexities faced by developers when considering how far to go. In simpler terms, it must be considered that if we can potentially develop robots surpassing human intelligence , this does not necessarily mean that we should.

2.3 Robots Today

Robots today are not simply mechanical arms designed to ease manual labour processes. Thanks to rapid advances in robotics and computer science, robots are now visible in everyday life. For many, a time without the omnipresence of robots is not within living memory.

According to the Robotic Industries Association, robotic automation is the future of manufacturing as they save money and time, can be scaled up and down to suit the industry and in turn, create more jobs. (Robotic Industrial Association, 2019)

Below is a non-exhaustive summary of major industries in which robots perform vital tasks, along with some examples. It would be impossible to provide an exhaustive list however this should provide a suitable overview for the purpose of this thesis.

- Agriculture
  - SmartCore

    SmartCore is an autonomous robot that collects soil samples using GPS and obstacle-detection algorithms. This eliminates the need for inefficient manual soil sampling and allows farmer to optimize processes and in turn, increase yield while driving down costs. (Hooijdonk, 2019)
  - Rubion

    Rubion is a fully autonomous strawberry-picking robot. In addition to picking and weighing fruit, Rubion can predict the upcoming harvest to support more efficient planning. With an ongoing agricultural labour shortage, it is expected that Rubion will allow market growth that was previously impossible. (Hooijdonk, 2019)

- Factory Production
    - Material Handling

      There are many types of material handling robots and they make up approximately 38% of industrial robots being used for this purpose. Material handling includes tasks such as loading and unloading, packing, palletizing and machine feeding. The presence of these robots eliminates the need for repetitive tasks and increases safety. (Calderone, 2016)
    - Welders

      Welding robots make up 29% of robots used in manufacturing, mainly spot and arc welding. The use of these robots increases precision, reliability and output. (Calderone, 2016)robots
- Medicine
    - Da Vinci Surgical Robot

      Perhaps one of the most well-known robots in the medical field is the da Vinci Surgical Robot. The multi-armed robot can perform less-invasive surgery and reduce surgical errors. By using magnified high-definition vision and controls, surgeons are able to carry out more complex operations than would have been possible using human vision and hands. (Case Western Reserve University, 2020)
    - The TUG

      On a very practical level, the TUG transports supplies, meals, linens and other materials around hospitals, eliminating heavy physical loads. A typical 200-bed hospital transports these items approximately 53 miles per day. (Case Western Reserve University, 2020)
- Retail
    - Bossa Nova Robotics

      Mobile robots from Bossa Nova Robotics are used to gather data in-store. As they move around, they pick up gaps in shelves and communicate information to human team members, allowing them to proactively restock the shelves. (O'Brien, 2020)

  - Marty, Badger Technologies

    Marty is a comical looking, 6-ft tall robot that detects spills and alerts workers to hazards as it roams around the store. (Case Western Reserve University, 2020)rib

- Finance
  - USAA

    USAA uses virtual agents to interact with customers. The ability of the robots to comprehend human behaviour is described as ‘digital empathy’. (Thomas, 2019)

  - Robotic Process Automation (RPA)

    RPA is a broad term used to describe a software-based workforce that can perform repetitive tasks, therefore freeing up humans for tasks that robots are not yet capable of. RPA is employed in a wide array of functions including trading, bank account opening, reporting, credit card reconciliation, fraud detection and prevention, regulatory compliance, invoicing, wealth management and mortgage processing. (Thomas, 2019)

- Education
  - Robin, Softbank Robotics

    Part of the European research project, L2TOR, Robin is a 23-inch-tall humanoid robot used to teach English to young children. Robin was trialled between 2016-2018 and involved 208 Dutch children. (Gottsegen, 2019)

  - Millenia, International Robotics Inc.

    Inspired by his work in the special education field, IRI’s founder Robert Doornic was inspired to create Millenia. Some children, particularly those with autism, have been found to communicate more comfortably with robots than with adults. In these cases, Millenia can support the human teachers and bridge the communication gap. (Thomas, 2019)

- Warfare
  - AI elements in military aircraft

    Both Russia and Japan have developed software for their fighter aircraft. The AI can be used to analyze external conditions and predict outcomes of – and override – certain manoeuvres. In the Japanese prototype X-2 Shinshin, AI is used to scan the entire aircraft for damage and reconfigure the system to compensate, effectively allowing it to continue action as before. (Sychev, 2018)
  - Unmanned Aerial Vehicles (UAVs)

    One of the more publicised and alarming developments is UAVs. As an example, developed by the United States, the General Atomics MQ-1 Predator and MQ-9 Reaper have been purchased by allies of the US and has seen action in the US invasions of Afghanistan. They have been used both to carry antitank missiles as well as to mark targets for points for more heavily-armed bombers. This is not to suggest that only the US and its allies have purchased or made use of UAVs. All major military powers employ battlefield surveillance UAVs.(John W.R. Taylor, 2009).

2.4 Operation of robots

To provide a meaningful overview, in describing the operation of robots I plan to focus primarily on physical robots that are replacing manual labour traditionally carried out by humans.

As can be seen in chapter 1.2., this is not the extent to which robots are being used. In addition to replacing manual tasks, robots are being used to perform tasks that would simply not have been possible for human hands as well as automating processes by way of sophisticated software.

2.5 Mechanical Overview of a Robot Arm

Robot arms are made up of joints and links – much the same as human arms. The links can be formed in either of the two configurations shown in the following illustration.

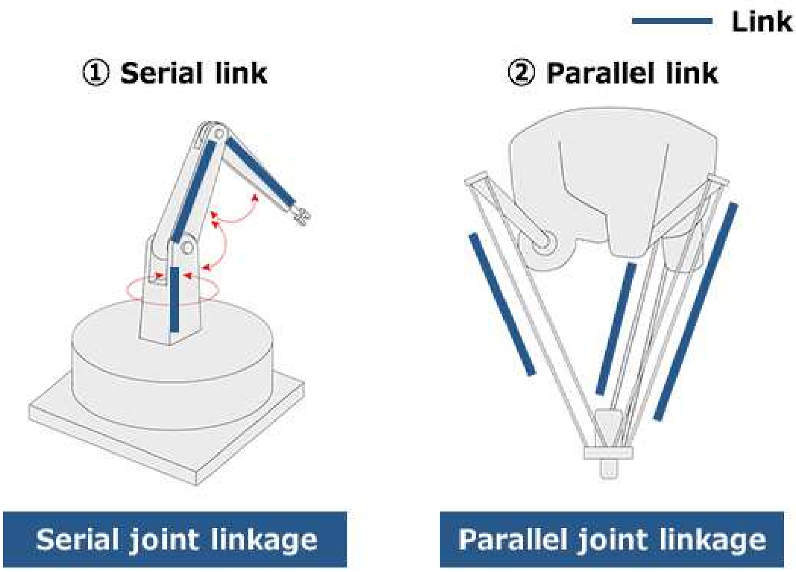

Figure 2 Illustration of serial joint linkage and parallel joint linkage (XYZ, 2018)

There are six major types of industrial robot:

- Polar Coordinate Robot - centrally pivoting shaft with an extendable robot arm

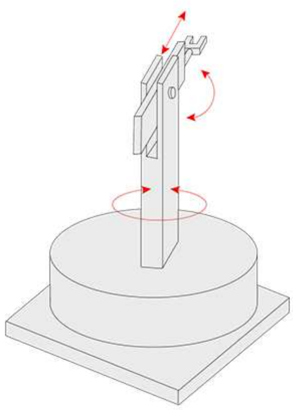

Figure 3 Polar Coordinate Robot Illustration (XYZ, 2018)

- Cylindrical Coordinate Robot – like the polar coordinate robot, however the arm moves vertically by sliding up and down, not rotating.

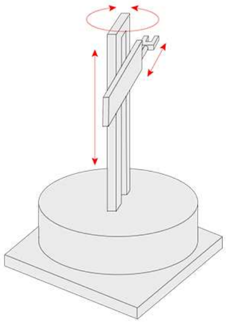

Figure 4 Cylindrical Coordinate Robot Illustration (XYZ, 2018)

- Cartesian Coordinate Robot – moves by sliding on three perpendicular axes.

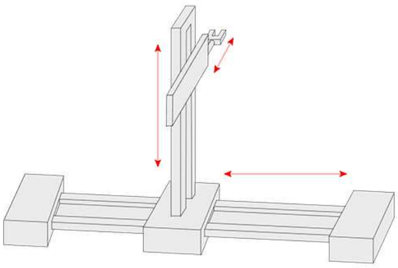

Figure 5 Cartesian Coordinate Robot Illustration (XYZ, 2018)

- Articulated Robot – similar structure to that of a human arm.

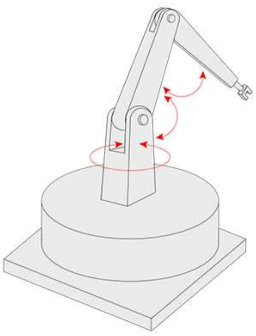

Figure 6 Articulated Robot Illustration (XYZ, 2018)

- Selective Compliance Assembly Robot Arm (SCARA) – this robot works on level surfaces by moving the arm at high speed before raising and lowering the effector.

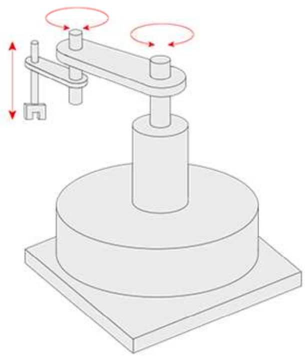

Figure 7 Selective Compliance Assembly Robot Arm Illustration (XYZ, 2018)

- Parallel Link Robot – with limited range but high precision.

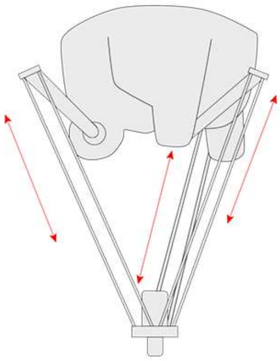

Figure 8 Parallel Link Robot Illustration (XYZ, 2018)

(XYZ, 2018)

As it would not be practical within the scope of this thesis to review all the 6 major robot arm types listed above, the overview of the mechanical overview will focus on the articulated robot, as this is the most common type of industrial robot today.

The below illustration shows a general-purpose robot from Kawasaki. It shows that there are six joints/axes.

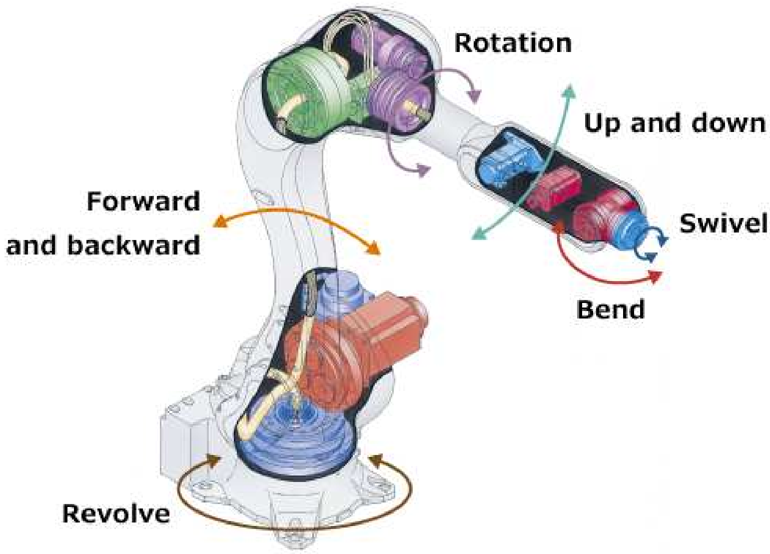

Figure 9 Illustration of a general-purpose robot arm from Kawasaki (XYZ, 2018)

There are four critical components within the robot arm:

- Actuator
    - This functions as the joint of the robot, converting energy into mechanical motion, as illustrated below. These motors require high precision. A highly functional 'servo' motor that can control position and speed is used for industrial robots.

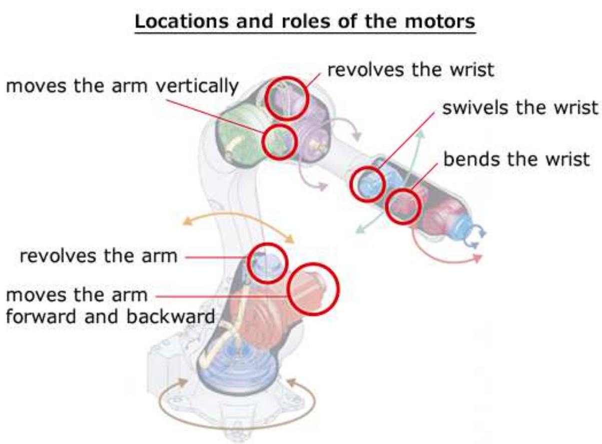

Figure 10 Illustration of actuators within robot arm(XYZ, 2018)

- Reduction Gear
    - Reduction gears are used to increase the power output of the robot arm, using the same principle as bicycle gears, for example.
- Encoder
    - Optical encoders allow servo motors to precisely control positioning and speed. It does this by providing data about the position of the motor's rotational shaft using a disk with slits at regular intervals and light-emitting-diode (LED). The photodiode is used to determine the rotation angle and speed based on the signals received from the light as it passes through, or is blocked by, the slits.

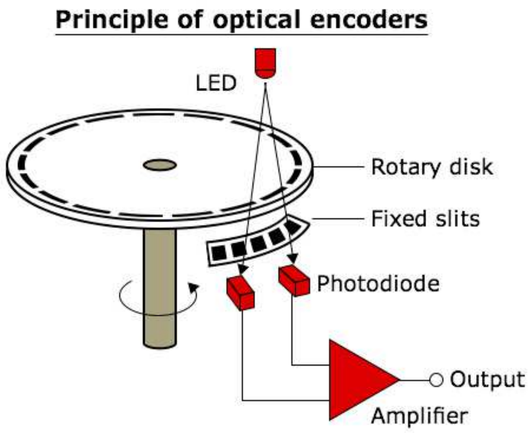

Figure 11 Optical Encoders Illustration (XYZ, 2018)

- Transmission
    - The transmission transmits the power generated by the actuators and reduction gears. Within the robot arm, it is capable of changing the direction and magnitude of power.

Figure 12 Schematic showing transmission within the robot arm (XYZ, 2018)

2.6 Practical Example - FANUC M-1iA Series Delta Robot

The FANUC M-1iA Series Robot is designed for high-speed small parts handling. It is lightweight, compact and can tolerate a maximum load of 1 kg and a work area of up to 420 mm. This robot is mountable, can be integrated into existing machines and promises human hand-like dexterity.

The robot is available with a 3, 4 or 6 axis design, depending on the application. (FANUC, 2020)

Figure 13 FANUC M-1iA Series Robot (FANUC, 2020)

The FANUC M-1iA Series has been used by pharmaceutical manufacturer Merck on their bottling line, placing bottle caps on allergy medications. Multiple variants of bottle can be processed using the robot, simply by selecting the appropriate program to run. (Markarian, 2014)

The main advantages of employing a robot for this task are speed (120 cycles per second) and safety – the use of robots means that there is no need for clean room compliance, as there would be if humans were completing the task.

Merck uses a 4-axis variant of the M-1iA and it is controlled by a 19” rack-mounted FANUC R-30iA Mate Controller.

The function of the M-1iA robot in this capacity is described below by AutomationFair:

‘A spiral conveyor on the robot cell lines up dispenser caps on a rail and a nylon worm drive positions bottles alongside. The robot grips a cap and places it on the bottle, which has previously been sealed by a screw-on cap. A simple encoder supplies the position data.

The M-1iA signals the worm drive to position the next bottle. A cylinder arrangement after the robot cell firmly presses the dispenser caps down onto the bottles. The capped bottles are then conveyed to the packaging machine. (AutomationFair, 2012)’

Figure 14 FANUC M-1iA series robot in use at Merck facility (AutomationFair, 2012)

3 METHOD

This section outlines a basic SWOT analysis (strengths, weaknesses, opportunities, threats) of robots, a basic survey of attitudes towards robots and the assembly and operation of a robot car kit.

3.1 SWOT Analysis

Based on the literature reviews carried out for this thesis, the following SWOT analysis outlines the author's considerations.

Table 1- SWOT Analysis

STRENGTHS	**WEAKNESSES**
• Improved safety • Improved efficiency • Reduced overhead costs • Can be used in jobs dangerous to humans	• High procurement costs • Requires infrastructure • Lack of trust/social acceptance • Lack of creativity and social intelligence • Sensitive data can be more vulnerable • Maintenance – service contracts will be required • Involves external suppliers • Quality control challenges
OPPORTUNITIES	**THREAT**
• Efficient use of staff leading to greater job satisfaction • Improve productivity • Safety guarantees	• Legal • Reputational • Staff morale • Speed of advancement – better models available to competitors at fast rate

3.2 Survey of Current Attitudes

To gauge the current attitudes amongst my peers, a basic survey was conducted using an online service – www.surveymonkey.com, which allows free surveys of up to 100 participants.

I asked 8 questions – designed to establish which social demographics my respondents belonged to and to gain an insight into the overall feeling towards robotics in our society.

The survey was set up and engagement was requested via LinkedIn and Facebook private networks.

The results are summarized in chapter 4.1.

3.3 ELEGOO UNO R3 Robot Car Kit

As part of the research for this thesis, the Elegoo Uno R3 Project Smart Robot Car Kit was purchased.

The car kit is an educational kit aimed at beginners (suitable for children) to get practical experience in electronics assembly and robotics knowledge.

3.3.1 Hardware

The kit includes:

- 1 x ELEGOO UNO R3
- 1 x USB cable
- 1 x V5.0 extension board V3.0
- 1 x L298N motor driver board V3.0
- 1 x ultrasonic sensor
- 1 x ultrasonic holder
- 1 x servo motor
- 1 x servo motor fixed plate
- 1 x line tracking module
- 4 x motor
- 1 x remote
- 1 x charger

- 1 x cell box
- 2 x 18650 battery
- 1 x tape
- 8 x separation shims
- 2 x acrylic plates
- 4 x wheel
- 8 x bags of screws and nuts for sensors and modules
- 4 x aluminium blocks
- 10 x copper columns
- 1 x plastic box
- 1 x CD with tutorial
- DuPont wires
- Fix tools

3.3.2 Software

The Elegoo UNO R3 kit uses Arduino IDE – a programming software that is widely used as it is easy-to-use for beginners while being flexible enough for advanced users.

The software runs on Windows, Macintosh OSX and Linux making it suitable for all major operating systems.

The software is open-source and can be expanded through C++ libraries. More advanced users can add ACR-C code – the programming language on which Arduino IDE is based.

As Arduino is an open-source platform, there are many online resources and communities for users to access. (Arduino, 2021)

3.3.3 Assembly

In terms of simplicity, the car kit was simple to complete. The process took approximately two hours with little difficulty. The instructions are clear, well-illustrated and easy to follow. The kit and completed model are shown below.

From new, it was noted that some of the pieces are delivered in reusable packaging while others are not. This prompts a small concern in the reusability of the kit between different students.

Figure 15 Detail image of Elegoo UNO R3 Kit (Amazon, 2021)

The result is a working remote-controlled car with obstacle detection and line tracking capabilities.

3.3.4 Operation

There are two methods to control the car once built. Each method was executed and summarized below.

3.3.4.1 IR Remote

Figure 16 Elegoo UNO R3 IR Remote

This is the simplest method as it is ready-to-use. The IR remote can be used in the following ways:

1. **IR-Remote Control Mode**

   The arrow keys are used to instruct the car to react accordingly.

2. **Obstacle-avoidance Mode**

   Key #2 will put the car into obstacle-avoidance mode. In this mode, the car will drive forward automatically and avoid obstacles using the ultra-sonic sensor.

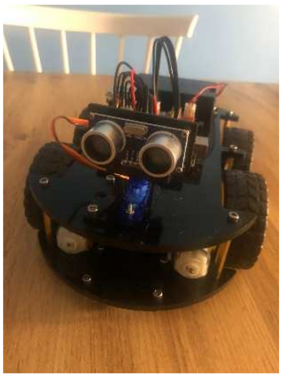

Figure 17 Photograph showing the ultrasonic sensor on the front of the car

3. **Line Tracking Mode**

Key #1 will put the car into line tracking mode. The 'track' is made using simple insulation tape. The car follows the insulating tape 'track' using the line tracking module on the underside of the car.

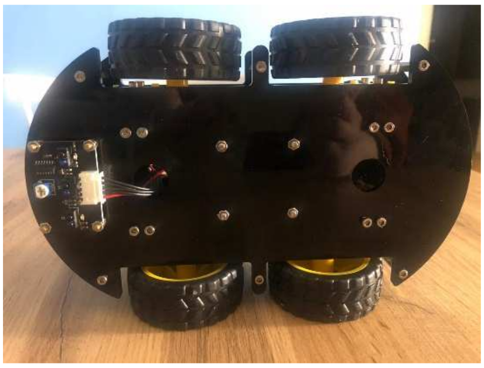

Figure 18 Photograph showing the line-tracking module on the underside of the car

3.3.4.2 Bluetooth App

The car can also be controlled using a Bluetooth App, available on the App Store and Google Play. After installing the Elegoo BLE Tool app, the car connects automatically using Bluetooth.

1. **Rocker Mode**

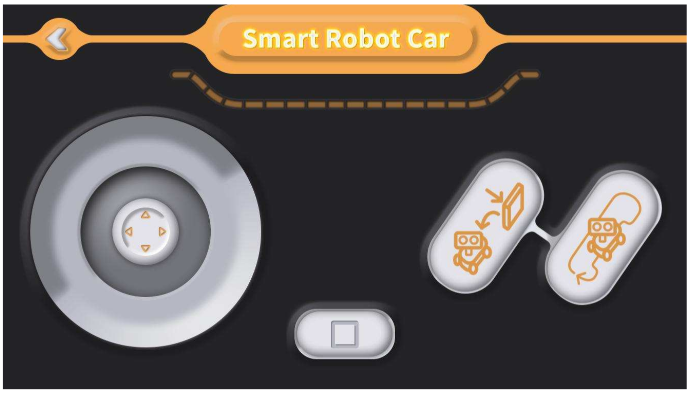

Figure 19 Screenshot of Elegoo BLE Tool App - Rocker Control Mode

In image 29, the rocker control can be seen along with the obstacle avoidance mode button and the line-tracking mode button. These operate in the same way as the arrows and keys #1 and #2 on the IR-Remote respectively.

2. Program Mode

The program mode within the app allows the user to select from pre-set menus and build a program for the robot to follow. This is a simplified version of modifying the code.

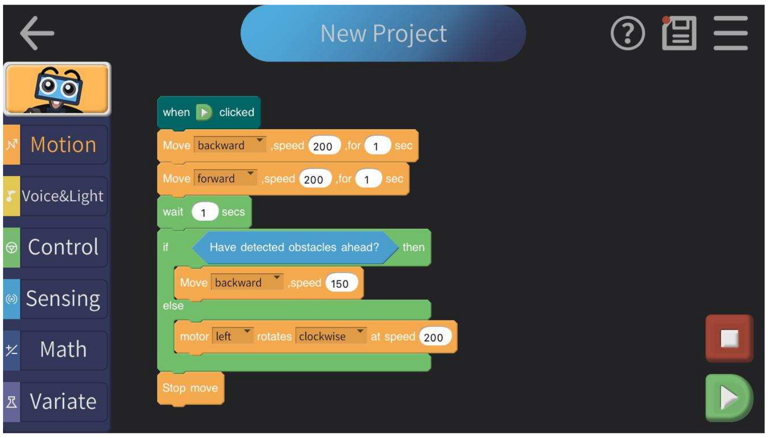

Figure 20 Screenshot of Elegoo BLE Tool App - Program Mode

3. DIY Mode

In DIY Mode, the user can build their own 'keyboard' of buttons.

Up until this point, using the app was very self-contained and no external information was required. In contrast, when opening the DIY mode section of the app, there is very little information or explanation of the purpose of this section or how to use it.

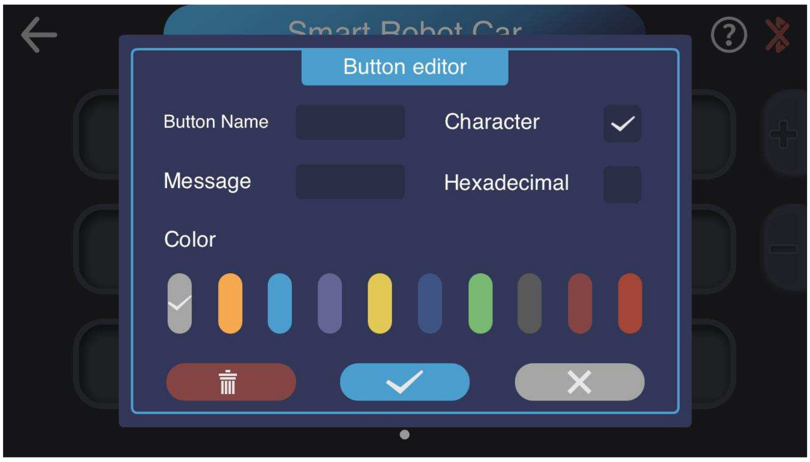

Figure 21 Screenshot of DIY Control Mode Within the App

The information shown in the below image was sourced from a video posted by Elegoo on YouTube.

Function	Message
Forward	f
Backward	b
Turn Left	l
Turn Right	r
Standby Mode	s
Line-tracking Mode	1
Obstacle Avoidance Mode	2

Figure 22 Screenshot of commands that can be used in DIY Mode (Elegoo, 2019)

3.3.5 Code

The car already has programs uploaded; however, it is possible to modify the codes used.

To begin doing this, the user must first install Arduino onto a computer. There are six lessons available to enable the student to learn about the code used for the car. Both the software and the lessons can be found at Elegoo's website (Elegoo, 2021).

3.3.5.1 Lesson Zero – Setting Up The Development Environment

In lesson zero, the user is guided through the process of installing the Arduino software and connecting the car to the computer. It is important at this stage to remove the Bluetooth module as it may interfere with the programs that will be uploaded to the car.

3.3.5.2 Lesson One – Make The Car Move

In lesson one, the user is guided through the basics of the car itself and uploading programs from Arduino IDE to the car. The lesson includes the code file to upload to the UNO board.

3.3.5.3 Lesson Two – Bluetooth Car

In lesson two, the user is guided through using the Bluetooth module and app. The lesson includes the code file to upload to the UNO board.

3.3.5.4 Lesson Three – Infrared Remote Control Car

In lesson three, the user is guided through using the IR remote to control the car. The lesson includes the code file to upload to the UNO board.

3.3.5.5 Lesson Four - Obstacle Avoidance Mode

In obstacle avoidance mode, it was found that the car repeatedly failed to identify an upcoming obstacle. As such, it would not stop and would continue to attempt to drive forward despite being stopped by a wall or item of furniture.

Figure 23 Screenshot of the obstacle avoidance program within the app

By accessing the code in lesson four from the Elegoo website and connecting the car to the computer, it is possible to view the code in real time. Interestingly, the code appears to perform correctly when connected to the computer, meaning that it moves 'forward' when there is no obstacle and when a hand is placed in front of the sensor, the 'forward' command stops, and the ultrasonic sensor moves from left to right.

It was found that the original code instructs the car to stop if an obstacle is detected less than or equal to 40 mm away. It was found that this was too little.

```
void loop() {
    myservo.write(90);  //setservo position according to scaled value
    delay(500);
    middleDistance = Distance_test();

    if(middleDistance <= 40) {
      stop();
      delay(500);
      myservo.write(10);
      delay(1000);
      rightDistance = Distance_test();

      delay(500);
      myservo.write(90);
      delay(1000);
      myservo.write(180);
      delay(1000);
      leftDistance = Distance_test();

      delay(500);
      myservo.write(90);
      delay(1000);
      if(rightDistance > leftDistance) {
        right();
        delay(360);
      }
      else if(rightDistance < leftDistance) {
        left();
        delay(360);
      }
      else if((rightDistance <= 40) || (leftDistance <= 40)) {
        back();
        delay(180);
      }
      else {
        forward();
      }
    }
    else {
        forward();
    }
}
```

Figure 24 Screenshot showing the original code - highlighted sections show the items to be corrected

The code was edited to instruct the car to stop if an obstacle was detected less than or equal to 200 mm away. In addition, the delay to execute the commands was shortened which seemed to improve the reactivity to obstacles.

```
void loop() {
    myservo.write(90);  //setservo position according to scaled value
    delay(200);
    middleDistance = Distance_test();

    if(middleDistance <= 200) {
      stop();
      delay(200);
      myservo.write(10);
      delay(500);
      rightDistance = Distance_test();

      delay(200);
      myservo.write(90);
      delay(500);
      myservo.write(180);
      delay(500);
      leftDistance = Distance_test();

      delay(200);
      myservo.write(90);
      delay(500);
      if(rightDistance > leftDistance) {
        right();
        delay(360);
      }
      else if(rightDistance < leftDistance) {
        left();
        delay(360);
      }
      else if((rightDistance <= 200) || (leftDistance <= 200)) {
        back();
        delay(180);
      }
      else {
        forward();
      }
    }
    else {
        forward();
    }
}
```

Figure 25 Screenshot of edited code - highlighted sections show what has been changed

3.3.5.6 Lesson Five – Line Tracking Car

In lesson five, the user is guided through the code used to operate the car via line-tracking.

3.3.5.7 Lesson Six – Smart Car Multi-function

In lesson six, the user is guided through the various control functions that are available on the app, as outlined in chapter 3.3.4.2.

It was found that after using the computer to upload code to the car, it was not possible to simply switch to using the Bluetooth app again, as the car would only operate on the last-uploaded code.

To resolve this, several methods were attempted without success, including using the reset buttons and uploading a blank code to the car.

It was finally resolved by accessing the 'Main Program' folder that can be found with the lessons. The

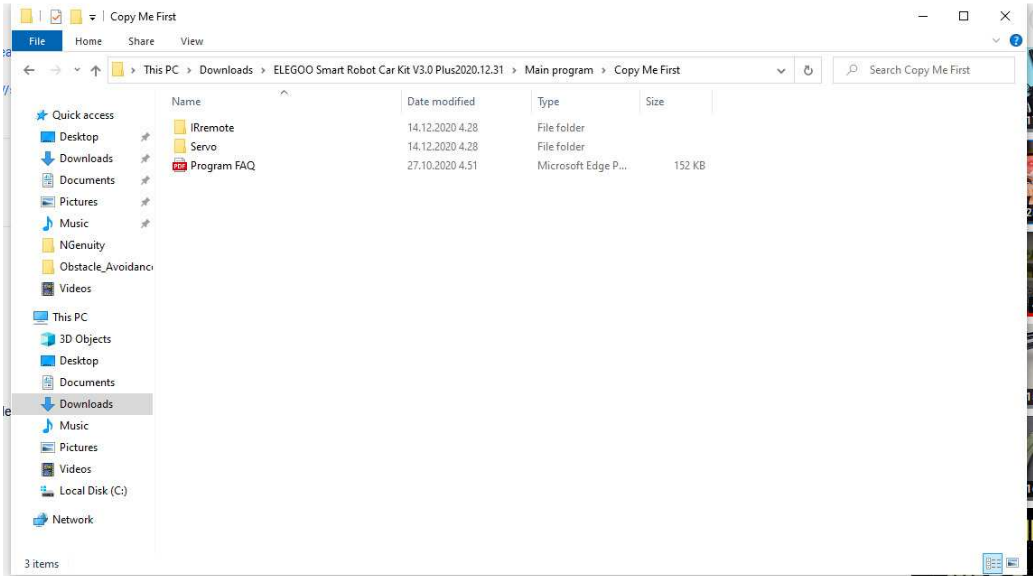

Figure 26 Screenshot of Main Program Folder.

Within this folder is a sub-folder labelled ‘Copy Me First’ where a PDF can be found labelled ‘Program FAQ’. After reading these and following the instructions, it was then possible to upload the core programming found in the SmartCar_Core_20201211 folder, file name *SmartCar_Core_20201211.ino* (Annex 1 – SmartCar Core Program).

Following this process will essentially create a factory reset and the car can then be used with Bluetooth.

The thought process involved in this solution was largely guesswork. The ‘Main Program’ folder and FAQ document was stumbled upon and thereafter, the logic was simply that ‘core’ programming would be the most likely way to restore the car to the original settings. Whilst this luckily turned out to be correct, it should be noted that this was not clearly outlined in any instructions and would may be difficult for a student with no coding background to resolve without assistance.

3.3.6 Trial Repeat Assembly

As this thesis concerns itself with a recommendation to Arcada to use such robot kits as an educational tool, the task was given to a third party without additional instruction to rebuild the car after it had been built from new and repackaged by the student.

4 RESULTS

4.1 Survey

4.1.1 Social Demographics

Participants were asked the following questions in relation to social demographics:

Table 2 - Survey Questions - Social Demographics

1. Age Group

Age Group (years)	**Response**
<18	1%
18-24	2%
25-34	33%
35-44	33%
45-54	7%
55-64	17%
65+	7%

2. Gender Identity

Gender’	**Response**
Male	40%
Female	60%

*Note that further options were provided however, 100% of participants responded within the gender binary of male and female. In the interests of simplicity, alternative options were not outlined in the results.

3. **Level of Education**

Level of Education	**Response**
High School	10%
College Diploma	17%
Degree (3-4 years)	43%
Higher degree (Masters or above)	30%

It can be considered from the above, that most survey participants are 25 years or older with higher education, therefore more likely to be working on professional roles.

4.1.2 Attitude Towards Robots

Participants were asked the following questions in relation to their attitude towards robots and artificial intelligence:

Table 3- Survery Questions - Attitude Towards Robots

1. **Are you concerned about your future job security as artificial intelligence develops and automates more job functions?**

Answer	**Response**
Yes	8%
No	79%
I have not given it much thought	13%

2. **Are you concerned about general safety in day-to-day life as artificial intelligence develops and automates more job functions?**

Answer	**Response**
Yes	34%
No	51%
I have not given it much thought	15%

3. **Do you have concerns for the general safety of future generations related to artificial intelligence?**

Answer	Response
Yes	48%
No	37%
I have not given it much thought	15%

4. **Do you have concerns for the financial/employment security of future generations related to artificial intelligence?**

Answer	Response
Yes	52%
No	36%
I have not given it much thought	12%

5. **Please choose which of the following fits best with your overall attitude towards the development of artificial intelligence:**

Answer	Response
Mainly positive	51%
Neutral	31%
Mainly negative	14%
I have not given it much thought	4%

4.2 ELEGOO UNO R3 Robot Car Kit

4.2.1 Assembly and Operation

Practically speaking, the kit was compact and safe to use. Assembly can be comfortably completed by one person in one sitting of approximately two hours.

All necessary tools are included, and the instructions are easy to follow.

Whilst the instructions are clear and straightforward, some small issues did arise in the operation of the car and these are outlined in chapter 3.

Overall, the kit makes an interesting learning experience that would be suitable for a small project or as part of a course on robotics.

4.2.2 Trial Repeat Assembly

The assembly of the car was completed in a similar timeframe and with little difficulty. The parts had been packed and labelled as far as possible by the student. However, it was noted that if no attempt was made to pack the robot car kit well after use, it would be more difficult and time consuming for the next student to repeat the kit. This should be stressed when assigning the kit to students.

One further concern is simply that many of the pieces are small and therefore easily lost although most of the smallest parts are fastenings and the like and the car would still function well with some of these missing. Fastenings are also of standard sizing and clearly outlined in the instruction manual and could therefore be replaced easily as needed.

After building the car, an issue was discovered in the Bluetooth connectivity that was not experienced during the first build. The first build was paired with an iPhone while the second was paired with an Android phone. It was found that the car itself could connect to the Android device, but the Elegoo BLE Tool app would not connect. Through some trial and error, it was found that this problem could be resolved by allowing the app to access the phone location. In trying to repeat the issue with the iPhone, it was found that the iOS operating system does not have any location settings for the Elegoo BLE Tool app, so the issue could not occur. For future students, it simply needs to be noted that Android users must manually give permission to the app to access location.

5 DISCUSSION

5.1 Survey

It is important to note in the first instance that 100 participants is not a high enough number to draw meaningful conclusions about current societal attitudes towards robots, but is merely a basic indicator of the attitudes within a very limited social demographic.

As can be seen in the tables above, only 10% of participants have an educational level below a college diploma and 73% holding a bachelor's degree or higher. This indicates that most participants are likely to hold professional roles that are perhaps less likely to be considered vulnerable to automation.

Based on the responses outlined above, it can first be seen that approximately 15% of respondents have not given much thought to the subject of robots and artificial intelligence.

Of those that have given the subject some consideration, it is fair to say that the overall attitude appears to be positive, albeit with some concerns related to safety and future security. Employment concerns relate more to the situation that will be faced by future generations, rather than the situation as it stands today. There is a notable gap between the number of participants who express concern for their own employment security (8%) and the number of participants who express concern for the job security of future generations (52%). This would perhaps suggest that participants see major advances in artificial intelligence as a problem for tomorrow that will not progress rapidly enough to cause much concern today.

Interestingly, concern for safety seems to be of significant concern for participants in relation to both current day (34%) and future generations (48%).

5.2 Future of Robots

5.2.1 Within Society

Advances in robotics have enabled significant developments in many areas of modern life from manufacturing to agriculture to medicine and many more and it is reasonable to expect that this is an area that will continue to advance, rather than regress.

Whilst it is inevitable that improvements in the capabilities of robots will result in losses of jobs, it is also important to consider that many of those jobs are dangerous or unpleasant for humans to perform. An obvious example of this would be bomb disposal robots but there are many more industries where the use of robots will make the working environment for humans safer and more pleasant.

In addition to the ‘on the ground’ improvements that robots can make to our working lives, jobs will also be created.

In the most acute sense, there will be increased need for people who can design, optimize, program, and operate these robots. However, though less immediately obvious, it must be considered that our existing frameworks are not built with a robot workforce in mind. For example, in today’s world, if a surgeon operates on a human and makes a mistake, the surgeon and his/her employer are likely to be sued and his/her career and professional license will be at risk. In a scenario where the surgeon is a robot, it is difficult to identify who would be held responsible as there are several possibilities including the robot designer, robot manufacturer, robot owner and the robot programmer. It is unlikely that this list is exhaustive, and it would require a specialized education to be able to consider who would be held responsible to pay reparations to the damaged party. There would also need to be systems in place to prevent future incidents. In our current system, a surgeon who makes a serious enough mistake will be removed from the operating theatre. This would not solve the problem with a robot, as removing one robot would not change the fact that there are likely many identical robots performing with identical code.

A surgeon is merely one simplified example of a very complex problem, the solution to which will involve a network of specialized professionals in roles that do not yet exist.

It is my view that it is without doubt that robots will disrupt our social landscape in ways that we likely cannot yet imagine however, it is also my view that this will lead to a redesigning of our lifestyles, rather than the destruction of it. Jobs will disappear, and others will take their place.

It may be the case that the redundant jobs will outnumber those created, either temporarily or permanently. However, given that in this scenario, the cost of production will likely decrease given that much of the work will be carried out by unpaid labour in the form of robots, what we may see is a reimagined social structure where initiatives such as universal basic income become the standard.

5.2.2 Within Educational Institutions

Within educational settings, it will become essential for children to be taught about robotics, robots, and artificial intelligence in the same way that it became essential for children in the 1990s and 2000s to learn to use computers.

As robots become commonplace in almost every industry, it will be necessary for the workforce of the future to understand them.

There are many toys and tools available on the market today to begin learning about these topics, aimed at children as young as six years old. According to RoboGarden, some countries are teaching children to code from kindergarten and now consider learning computer science education to be as important as language or mathematics. (RoboGarden, 2020)

It is my expectation that we will see a transitional period where both secondary and tertiary educational facilities are using the same materials to teach their students about robots, such as in the case of this thesis where the robot car kit being discussed is suitable for use by children of age twelve years and older.

The reason for this is simply that the students moving through higher educational settings do not have any background in robotics, as this did not form part of their secondary educational curriculum.

I would expect that within the next five to ten years, robot kits such as the Elegoo UNO R3 Robot Car Kit would be insufficient to advance the knowledge of a University of Applied Sciences student and this must be taken into consideration by the administrators of these curriculums.

6 CONCLUSION

The aim of this thesis was to make some level of prediction about the future of robots as well as provide some meaningful recommendation to Arcada for future curriculum material.

The future of robots in our society is a vast topic with need for many complex considerations far beyond the scope of one bachelor’s thesis. However, this thesis gives a brief insight into the status of robots in industry from an engineering standpoint and considers the future potential of a world with increased robot presence.

This was considered in tandem with the current social attitudes and concerns surrounding the development of robots, as it is not possible to consider the future of robotics and artificial intelligence without understanding and addressing the legitimate concerns of the humans they will be working alongside. These two issues are closely intertwined and any conversation about one should include the other.

It can reasonably be concluded that the presence of robots in our society will increase however, this may well lead to an improved quality of life for citizens of those societies with increased safety and security. This may be reflected in the surprising lack of concern exhibited by the survey participants in terms of job loss and job security. This may demonstrate that people are optimistic for the future with increased robot presence in all aspects of life, rather than feeling apprehensive of it.

From an educational perspective, the continued development of robotics underlines the importance of educational institutions to work with and support students to ensure that they are ready for the evolving job market and opportunities that lie ahead.

The Elegoo UNO R3 kit is a useful introduction to robotics however, as it is designed for use by children, it is easy to complete the kit without learning much about the hardware or software in any depth. This could be remedied with targeted assignments ensuring more in-depth learning outcomes are achieved.

The advantages of a kit like this for a higher education setting is that the Arduino software is open-source and flexible, so there is plenty of room for users to deepen their knowledge. In addition, it is low-cost, compact, and safe making it an accessible and low-risk addition to the curriculum.

In summary, the Elegoo UNO R3 kit could be beneficial for students of the Materials Processing Technology programme however, the learning outcome should be clearly defined to ensure that students do more than simply follow the assembly instructions.

7 ANNEXES

Annex 1 SmartCar Core Program

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