EE2614 Experimental Digital Futures

The Research and Exploitation of an Emerging Technology:

Ubiquitous Robotics

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In this report, I will be exploring the emerging technology known as ‘Ubiquitous Robotics’. I will start with research into the history of the technology itself, as well as other relevant projects, products and events that have contributed to its current state in 2017.

Once I have a clear understanding of the technology’s history, I will explore how it actually works. I will proceed to review numerous existing ubiquitous robots in order to broaden my understanding of the potential for the technology. My research will be concluded with an exploration into the current tools available for developing a ubiquitous robot.

Using my research, I will then design my own exploitation of the technology and evaluate it with an exploration of how it could affect people, organisations and society in the form of a design fiction.

A ubiquitous robot (or ‘ubibot’) is a type of robot that exists within an environment in which everything is connected via the internet. This allows for the robot to appear ever-present by interacting with users and other systems in a variety of ways in both the digital and physical worlds[1].

There are four characteristics of ubiquitous robotics; all devices must be networked, user interfaces must operate fluidly, every device must be accessible at any time, from any location and all devices must function effectively in different situations[3].

It is currently assumed that there are three core components required to form a true ubiquitous robot[2], which are explained below.

1. **Software Robot (or ‘Sobot’) -** Virtual presence of the robot appearing within devices. There would be no geographical limitation and it would act as the master system controlling the physical components. It must have a self-learning, contextually-aware artificial intelligence that allows it to receive and respond to commands given by the user.

2. **Embedded Robot (or ‘Embot’)** - Intelligence control system embedded within real-world environments. It would respond dynamically to any environment in which it is placed and feed the gathered information back to the master system. It would also aid the mobile robot in responding to uncertain environments[4].

3. **Mobile Robot (or ‘Mobot’)** - Physical body capable of movement, performing physical tasks and interacting with the real-world environment.

The majority of current development in the field of ubiquitous robots have been in creating personal assistants and replacements for human workforce in a variety industries, from catering to the military. Sophisticated machine learning, rapid processing and bespoke hardware mean that a ubiquitous robot could solve problems and perform tasks more efficiently and cost effectively than human alternatives.

It is certainly not without any concerns. Devices being given advanced artificial intelligence as well as the access to a large amounts of personal data will certainly result in corporations and governments relentlessly surveilling citizens in questionably ethical ways. If the technology gets into the wrong hands it could be used for very serious criminal activity that may not even involve human assailants.

Initial growth and investment into robotic technology started due to the steady increase in population and quality of life across the world after World War II. Many people now had a disposable income and more of a choice in how they made their living. Automated machines which were more precise, faster and a lot more cost-effective than any human alternative started being installed in factories to keep up with the demand for new products and services in Western society. The majority of the largest and most profitable corporations on the planet are the current leading investors into robotics.

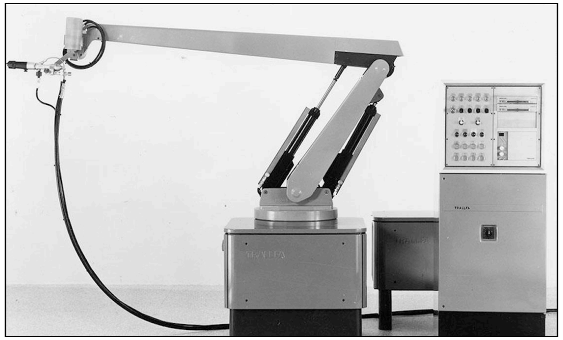
As well as this, more secretive investment and interest in robotics and artificial intelligence have been in applying it to military uses as well as space exploration; robotics would likely be a safer and more precise alternative to human soldiers equipped with accompanying technology. An artificially intelligent machine could also work remotely without human interaction, from somewhere like a battlefield or even a different planet.

3.2 Timeline

1950 - Alan Turing first proposed the 'Turing Test' to determine an artificially intelligent being. The contemporary idea of what a robot could be had only properly existed post-World War II due to the sudden investment into computer technology and a total change in the quality of life for humans in developed nations[9].

1954 - An industrial robot known as Unimate (pictured in Fig. 2) was developed by George Devol and sold to General Motors. This initiated what was known as the industrial age of robotics, which affected all industries and replaced thousands of human workers worldwide. This was a radical change. Once it started, investment and attention into what robotics could be used for increased[10].

Fig. 2 Unimate, George Devol's industrial robot sold to General Motors which replaced an enormous amount of human workers. Similar technology is still used today[11].



1969 - ARPANET was created, from concepts developed by team of computer scientists including Leonard Kleinrock. This was the first network to implement TCP/IP and a precursor to the World Wide Web[12].

1977 - The personal computing era begun when the Apple II computer (see Fig. 3) was released, developed by Steve Wozniak and marketed by Steve Jobs. This initiated mainstream popularity for personal computers[13].

Fig. 3 The Apple II computer[14].

1986 - Mark Weiser coined the term 'ubiquitous computing' and outlined set of principles for ubiquitous computers[15].

1989 - Tim Berners-Lee proposed the World Wide Web, which he developed at CERN. This would then transform the world as it was known and allow for devices to become more knowledgeable, useful and connected[16].

1997 - A supercomputer created by IBM called Deep Blue beat the world champion at chess[17]. This was the first notable achievement by an artificial intelligence and was highly publicised.

2002 - Rodney Brooks' company, iRobot, released Roomba (pictured in Fig. 4).

The Roomba would rapidly gain popularity to the point of mainstream success[18].

Fig. 4 A recent iRobot Roomba 650 model[19].

2004 - Jong-Hwan Kim coined the term 'ubiquitous robotics' and along with a team at KAIST, developed a proof-of-concept for the technology.

2005 - Honda's ASIMO (Fig. 5) was publicly shown to be able to walk as smoothly as a human, perform tasks and speak with basic machine learning capabilities[20].

Other robots similar to ASIMO started to replace professionals in the customer service and catering industries, though this is currently only largely noticeable in Japan.

Fig. 5 The body of one of Honda's Asimo humanoid robots[21].

2011 - IBM Watson beat previous champions on the American quiz show *Jeopardy!* and started to be used for commercial purposes. This was arguably the first notable use of artificial intelligence for consulting and data analysis in business[22].

2011 - Apple's Siri was released as a smartphone application that was able to use natural language to answer questions, perform tasks and make recommendations[23]; the first mainstream successful application of its kind.

2011 - IPV6 was launched publicly[24], allowing for billions of devices to be given an individual internet address.

2015 - The final DARPA robotics challenge was won in record time by HUBO[25], an advanced humanoid robot developed at KAIST (see Fig. 6).

Although the win was impressive and historic, HUBO succeeded by being able move using wheels as a backup for when bipedal walking became too challenging.

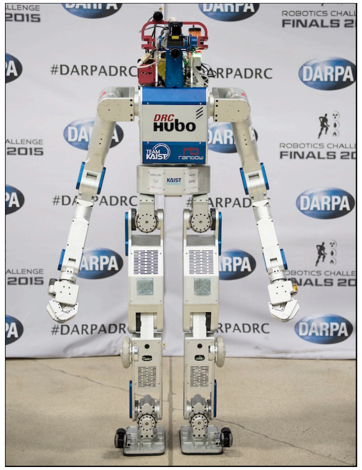


Fig. 6 The body of the winning HUBO model[26].

2016 - Google DeepMind's AlphaGo program defeated Lee Sedol, the world champion of Go. Initiated by Demis Hassabis, AlphaGo was a general-purpose artificial intelligence system, meaning that it was not specifically designed for one task like previous successful artificial intelligence programs[27].

4.1 Environment

A ubiquitous robot (see Fig. 11) requires an internet connection, which allows for the required components to connect to the secure remote server which contains the sobot, management system and back-end to the robot. This would be the ubiquitous space (see Fig. 7), where the wireless network standard at time of real-world deployment for this technology would be IEEE 802.11ax. A possible assumption for the environment that could enhance the ubibot's functionality would be a space that already contains many external sensors with microprocessors conveying information to networked devices publicly[4][7].

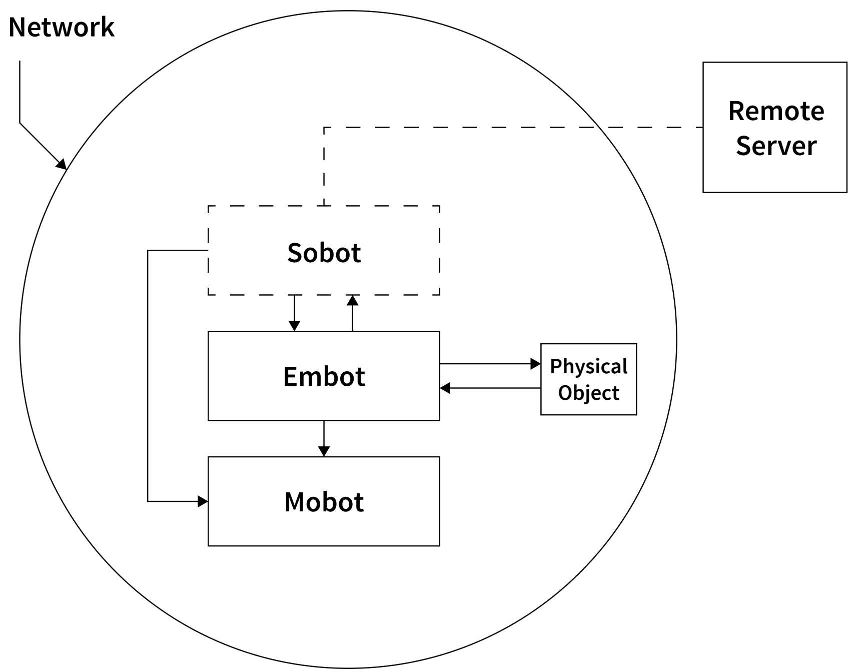


Fig. 7 Diagram of a ubiquitous environment[2][6].

4.2 Device Management System (DMS)

This is the user's management system that would also act as a back-end to the system[2]. It would be accessed through a web or native application installed on the user's preferred device, potentially in the same application that the sobot will manifest itself[1][5]. The DMS will request device description from the device in which it is installed upon as well as the embedded and mobile robot. Settings modified in the DMS will then be applied to each component of the ubiquitous robot remotely.

4.3 Software Robot (See Fig. 8)

In most instances, the software robot would function much like a virtual personal assistant[1][2]. It would be physically stored on a remote secure server and accessed via the internet through the user's device of choice and effectively share control over the entire robot along with the user.

The software robot would receive initial commands from the DMS' settings page. These settings can then be configured throughout the product's life and always override the software robot's artificial intelligence. They would govern permissions and what user data the software robot is able to access. The software robot would also contain advanced machine learning[2], which is what would allow it to make decisions based on contextual information as well as even develop a 'personality' in response to its user over time[8].

The software robot's user interface is very important, as this is how most of the ubiquitous robot would be controlled by the user. It must be responsive for different sized-devices and able to make use of the device to gain certain information (eg. location). The software robot would be communicated with through either text or voice commands through the user interface, taken in as raw data and processed into manageable commands which it would then proceed to act upon.

Another major way in which the software robot would receive information would be through the embedded robot. The embedded robot's processed environmental data would be fed back to the software robot, which would use this data to aid it in decision-making as well as to control both the mobile and embedded robots further.

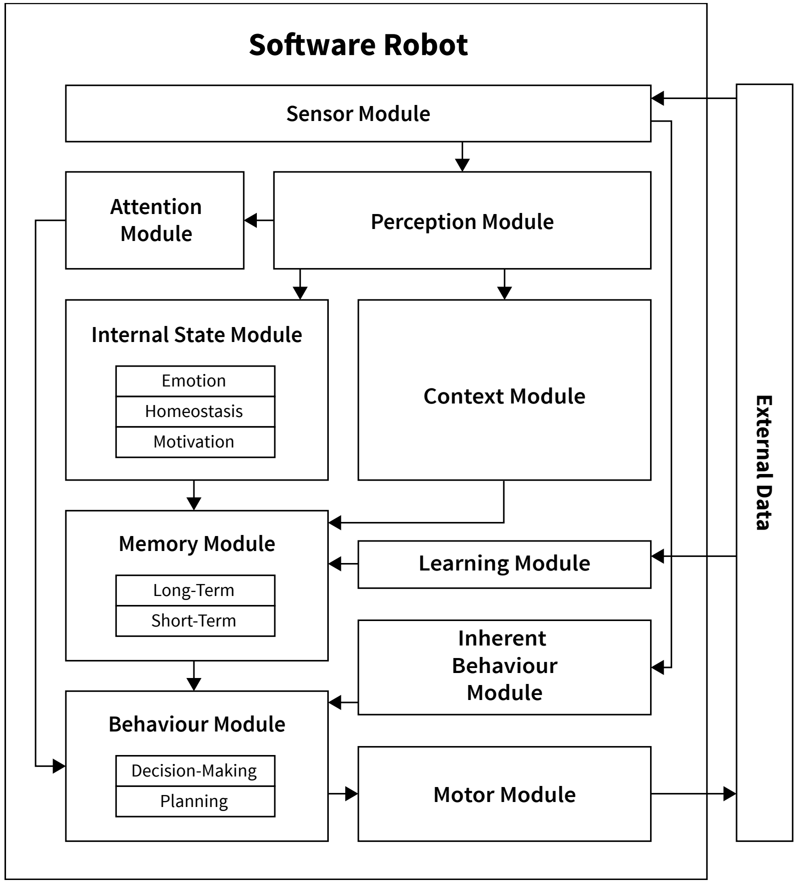


Fig. 8 General system architecture of a software robot[2][6][7].

4.4 Embedded Robot (See Fig. 9)

The embedded robot's body is irrelevant at this stage, as it is the sensor components and their capabilities that define its function and would change depending on the ubiquitous robot's purpose.

The sensors would collect data from the environment in which they are placed. The body of the embedded robot must be very small and able to blend seamlessly into the environment, which it would achieve through use of microprocessors. These would then process the raw sensor data and convert into meaningful information which would then be sent to the software robot to contribute towards further decision-making[3][4].

Because the embedded robot would be often be contained in a physical body in a real-world environment, it would be equipped with an RFID tag containing further information fed back to the software robot and user's device management system[6]. The embedded robot would be connected to the DMS so that it can be controlled by the user directly as well as by the software robot. In many proposed designs for ubiquitous robots, the embedded robots are often built inside the mobile robot itself[30][31], meaning the resulting hardware is one single robot that is then controlled by the software robot but makes use of artificial senses that are embedded robots placed about its body.

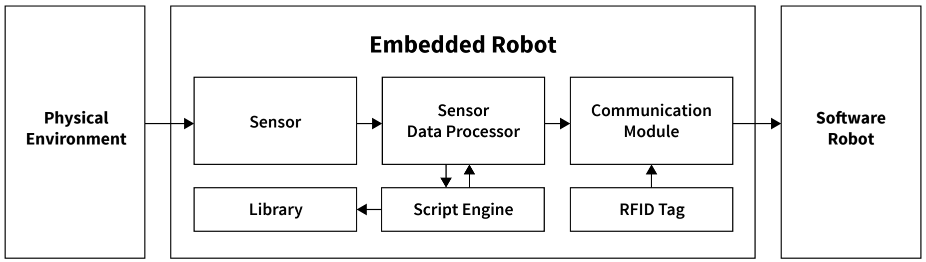


Fig. 9 Primitive embedded robot system architecture[1][2].

4.5 Mobile Robot (See Fig. 10)

The mobile robot's physical components are also irrelevant at this stage as the particular design for body of the robot would depend on its particular application. The leading requirements for the mobile robot are that it must be mobile and capable of interacting with and manipulating the physical environment[1][2]. Its mobility could perhaps be achieved through legs, motorised wheels or even propellers allowing for it to fly. The interaction with the physical world could be achieved through arms, specific mechanical tools or even audio commands using a microphone.

The mobile robot could be equipped with embedded robots on or inside it as well as a computer in which the software robot would be installed in order to be able to control it[4]. Due to the mobile robot being a physical entity, it would also require an RFID tag for the software robot and user to know where it is located. Commands made by the user via the DMS should also be able to alter the mobile robot's core abilities.

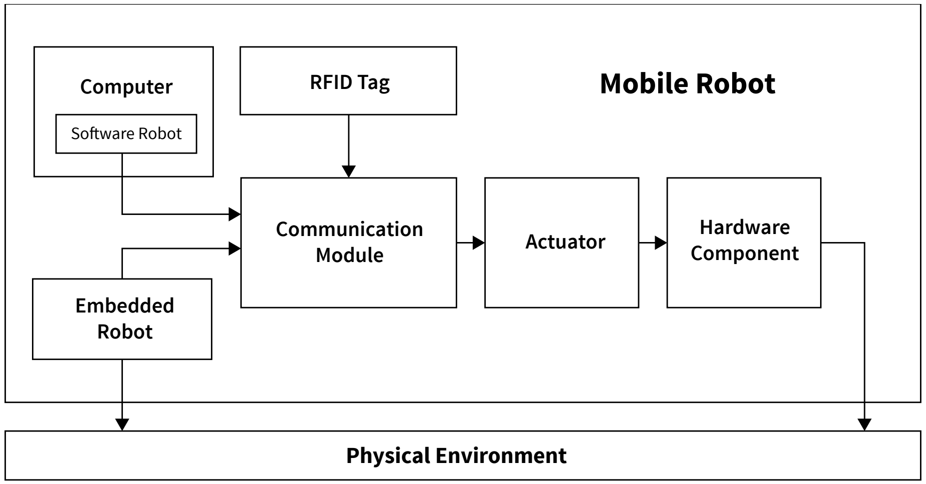


Fig. 10 Mobile robot system architecture[4].

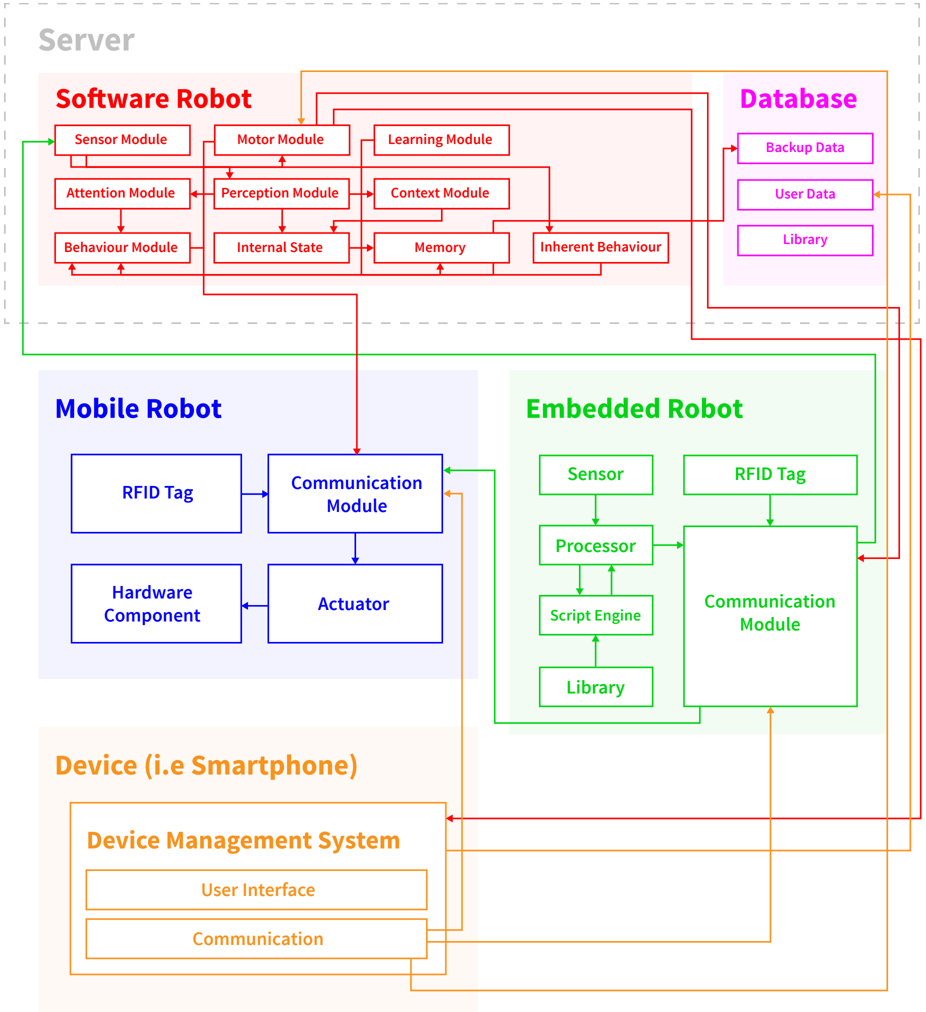


Fig. 11 Overall components and connections for a ubiquitous robot[4][5].

5.1 Proof of Concept[1][4]

A prototype for a ubiquitous robot named ‘Ubibot’ (pictured in Fig. 12) was initially created by Kim Jong-Hwan and a group of researchers at the KAIST robotics lab in 2004. The project was initiated as an attempt to create an artificial creature with primitive yet genuine emotions and motivations, which were then used to calculate its behaviour and choices without the need for human interference.

The piece consisted of a software robot named ‘Rity’, a mobile robot named ‘Mybot’ and three embedded robots equipped with specific sensor modules as well as a communication module to piece the entire ubiquitous robot together. The first embedded robot made use of a USB camera sensor with a facial and colour detection module. The second embedded robot employed a limited voice and speech recognition system through obtaining and analysing the ambient noise level of a recording. The final embedded robot was used to aid the system in positioning itself. In order to do this, it utilised an array of RFID sensors placed on the floor, with a PCB antenna to transmit radio signals s back through to the communication module.

The software robot ‘Rity’ (visualised in Fig. 13) was initially developed as a separate research project focusing on artificial intelligence that is driven by its own motivations, referred to as an ‘artificial creature’. It had 14 internal states, 47 perceptions, 5 facial expressions and able to exhibit 77 behaviours, as well as its own internet protocol address.

Rity used five key modules to respond to external stimuli in order to make its decisions; perception, internal state, behaviour selection, learning and motor. The perception module was able to interpret the data received from the external embedded robot for vision, therefore assessing an environment and transferring this processed information to the internal state module.

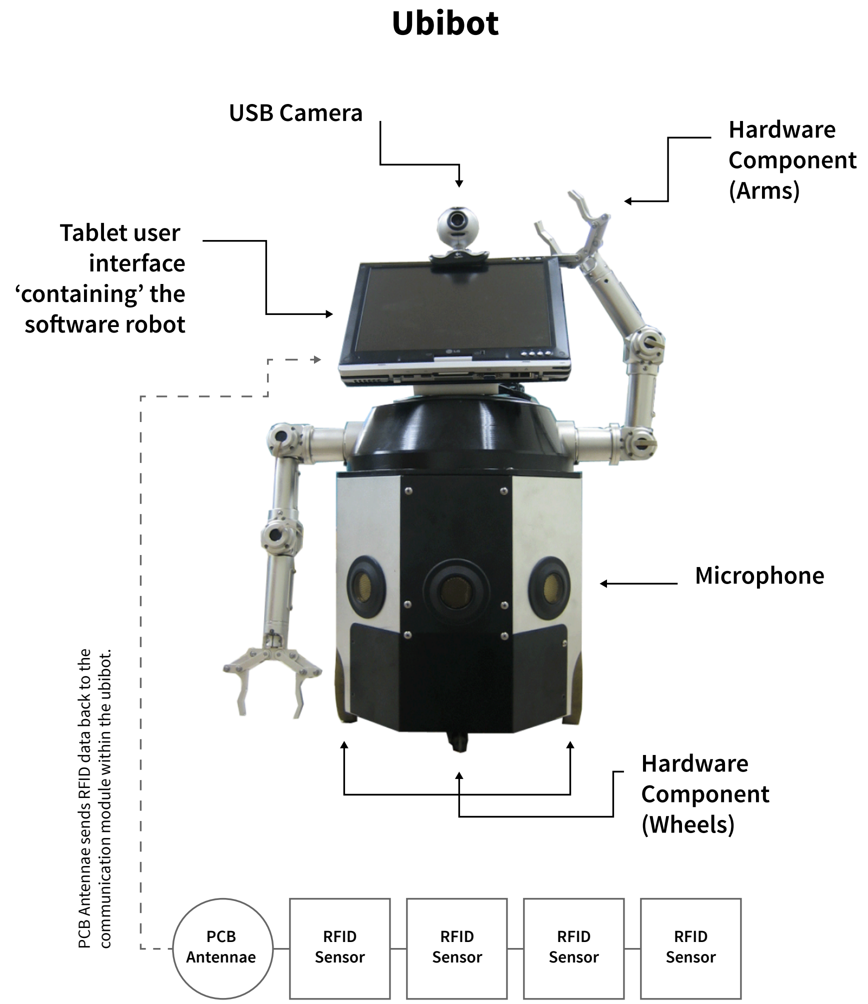


Fig. 12 Visual description of the revised Ubibot project developed at the KAIST robotics lab in 2006[4][5][7].

The internal state module defined Rity's motivation, homeostasis and emotion. Motivation was formed by six states; greed, curiosity, intimacy, monotony, avoidance and desire to control. Homeostasis was formed by three states; fatigue, hunger and drowsiness. Finally, emotion included five states; happiness, sadness, fear and neutral. The way in which external factors would have affected each particular status would have been preprogrammed in the robot's 'artificial DNA'. The internal state module heavily contributed toward the final behaviour and decision making of the robot.

A 'voting mechanism' was employed for the behaviour selection module. Data from the internal state module would be interpreted and contribute toward different behaviours, which would then be passed through an algorithm. This would calculate the most appropriate behaviour depending on the situation.

The learning module was comprised of two units, preference and voice learning. It was based on how domestic animals like dogs learn from humans. The motor module is what would execute the selected behaviour, and is directly connected and able to control the mobile robot. This was a wheeled autonomous robot equipped with pan-tilt cameras, ultrasonic sensors, wireless network access and another PCB antenna to respond to data from the positioning embedded robots. A touch-screen tablet was used as an interface so that the user could directly interact with the settings for the device as well as the software robot.

The Ubibot project was an effective proof of concept for a self-learning artificial creature that existed in both the virtual and physical worlds, able to make decisions for itself and manipulate objects in both of these environments. However, it had no real purpose other than to prove the concept and mirrors nothing but a real-life pet. A commercial application for this particular project could have been a service where customers are able to design their own artificial pet/companion's DNA to fit their particular needs and preferences.

It would be interesting to view the project be re-developed with more modern and fluid hardware. External embedded robots that are relatively large in size are not user friendly in the slightest or even ubiquitous in the true sense of the word. Modern ubiquitous robots make use of much smaller, embedded devices that simply form part of the mobile robot body and appearing invisible to the user.

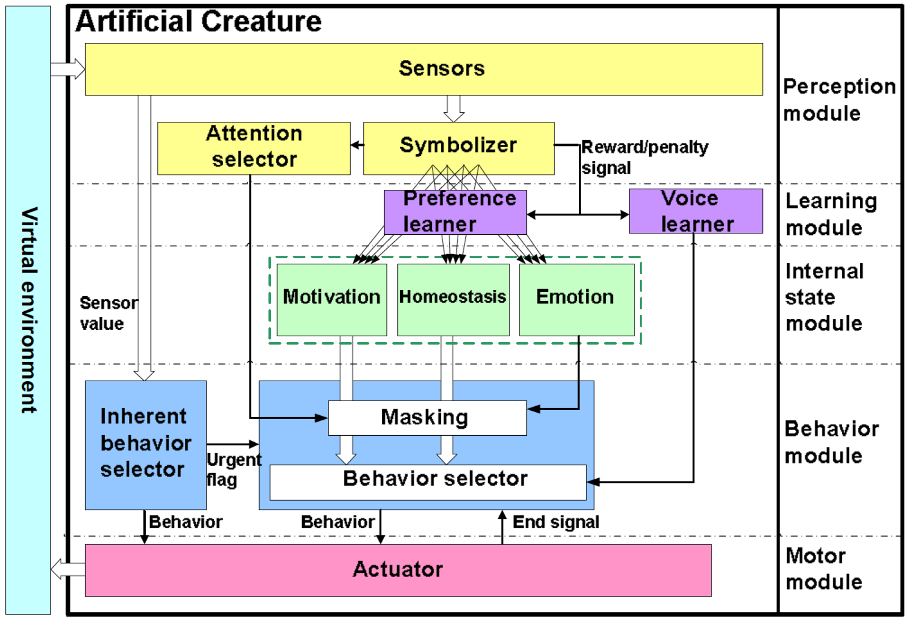


Fig. 13 Internal architecture of Rity, the software robot used on the Ubibot project[5][7].

5.2 Cleaning

Robots for cleaning were an effective introductory application for robotics into society as cleaning tasks are often unpleasant and can be easily automated. iRobot's vacuum-cleaning robot known as Roomba was arguably the first commercially successful ubiquitous robot. Aside from Roomba, robots have been used for cleaning in other ways such as for sewer-cleaning and more recently, mopping floors.

Roomba makes use of an automated body designed to move over the floor it is placed upon and uses external and internal sensors to guide it through the location. The body makes use of two motor-driven wheels which steer itself by alternating the power supplied to each wheel. It uses iRobot's robotic operating system known as the AWARE Robotic Intelligence System, which allows it to make decisions alone[28]. The system is made from numerous sensors that take in and process environmental data and then transfer this to the robot's microprocessor to make its decisions. Roomba navigates by sending out infrared signals (see Fig. 14) and measuring the time it takes for these to 'bounce back' after reaching a surface. It sends out a continuous infrared signal beneath the front of the body facing the ground to determine whether or not it is approaching an edge and uses an infrared signal and receiver facing forward to determine whether it is facing anything in its way. It then uses a further infrared signal located on the right side of the body which allows the robot to follow walls and other objects closely without disturbing them. The cleaning path is decided upon using a pre-set algorithm that allows it to maximise any floor coverage effectively[28].

An infrared receiver is used to re-locate the external charger when it has finished, as well as detect the 'virtual walls' which also emit a different infrared signal, artificially blocking its path. These are positioned by the user. More recent models include a mobile application with which the user can communicate with Roomba remotely.

The core technology behind the Roomba has not changed much in the 15 years it has been in production, aside from subtle improvements made to maximise productivity. Roomba serves its purpose well, but is not a particularly effective or interesting example of an application for ubiquitous robotics due to its rather basic structure and limited purpose. The embedded systems, in this case 'virtual walls', are rather large and should ideally appear invisible to the user in the environment.

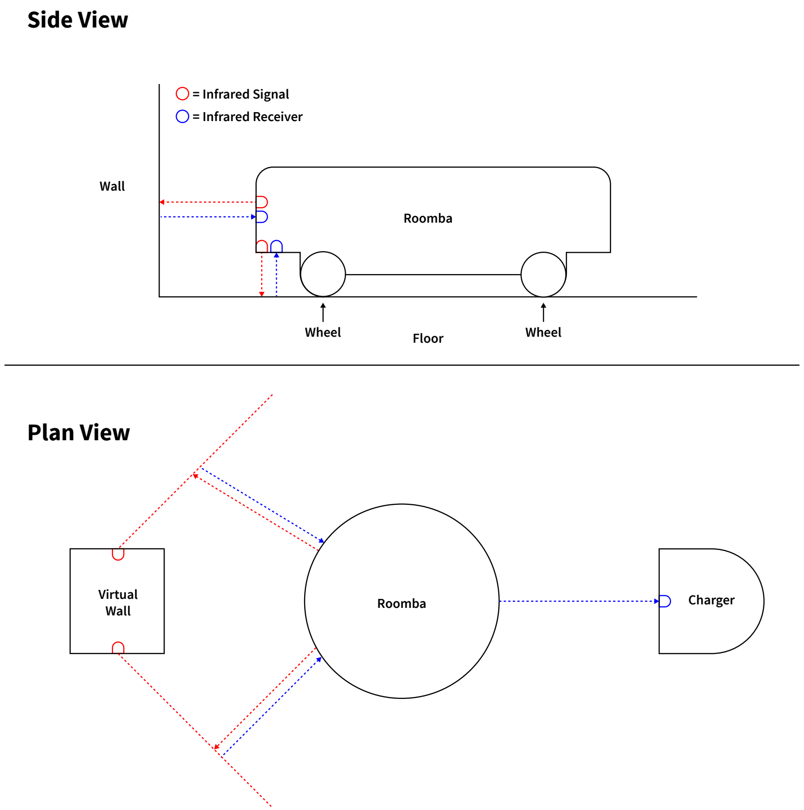


Fig. 14 Diagram showing how Roomba and its accompanying devices use infrared signals and receivers to navigate about its environment[28].

5.3 Home Security

CES 2017 exhibited an extensive list of personal-assistant type robots, each with differing specialist functions. A particularly interesting example which received a moderately large amount of media attention was Kuri (see Fig. 15), which I will proceed to focus on in-depth. Its precise purpose has been left curiously vague by the manufacturers, but it appears to act as a general-purpose household assistant as well a home-security robot. It has a very unthreatening and friendly design which was likely used to encourage users to entrust the robot with so much of their personal data.

In this instance ubiquitous robotic technology is exploited to essentially create a non-threatening security device that is able to monitor the home autonomously, although it can also be controlled via a smartphone app. Its core body functions very similarly to the Roomba, utilising lasers and mapping sensors as well as wheels to navigate itself about an environment. It is more technologically advanced than Roomba, as it is also uses capacitive sensors to allow it to respond to human touch, a powerful camera within its head to capture images and video, microphones to record, locate and react to sound and speakers to emit sound. It is also able to connect to any device over a network using IFTTT applets[29][30].

Like Roomba, it would not be correct to label Kuri a true ubiquitous robot. This is partly because it does not have a software robot counterpart, only a digital control system which also acts as a communication tool for the user to interact with Kuri even when not in the same location. Kuri also lacks an advanced artificial intelligence system. However, it does have primitive machine-learning capabilities, such as being able to learn the floor layout of a house as well as appear to express near-human emotion using an ambient coloured light on its body. This is linked to and controlled by a specific emotion-processing module located within its main processor[30].

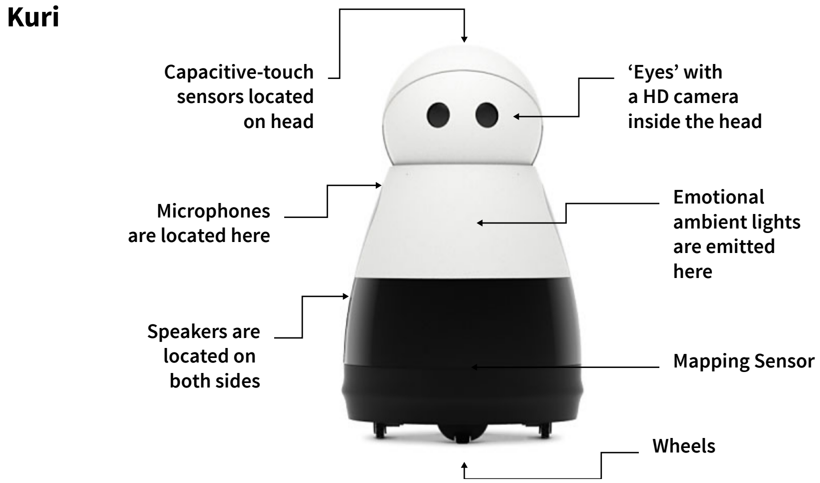


Fig. 15 The robotic body of Kuri labelled with features[30].

5.4 Manufacture

Robots have been used in industrial manufacturing since the 1950's, however, Rethink Robotics created a new sort of industrial robot which implemented a software presence as well as a physical body. Known as Baxter and Sawyer (pictured in Fig. 16), they are incredibly flexible and able to perform tasks with advanced precision, such as knitting and even PCB handling. What separates these robots from typical factory robots is their ability to work *with* humans instead of solely to replace them. The robots' system has a friendly software interface, which manifests itself in the form of humanoid eyes on a tablet-like device. The robots also have an accompanying digital service for monitoring how the robots visualise their environment and are trained. Although the robots are specifically designed for manufacture, the investment into a software presence for the robot as well as a physical one means that it could be installed on any computer device, including a server and then accessed over the internet through a multitude of devices. They are still at an early stage in becoming true ubiquitous robots, as they lack advanced machine learning. However, they remain a powerful example of how important both a physical and software presence are in the connected age, for both efficiency as well as in improving human-computer interaction[33].

Fig. 16 The Sawyer model from Rethink Robotics[32].

5.5 Personal Assistant

Many large technology companies have released their own virtual-personal assistant now, such as Apple's Siri and Microsoft's Cortana. What separates Amazon's Alexa from these is how it was treated as the main feature, as opposed to being a smaller component to a main device. Alexa is a personal assistant capable of performing numerous digital tasks for the user through voice interaction as well have control over other smart devices. Alexa is located on a remote server and accessed via a variety of smart devices which can be used as an interface for it, such as the Amazon Echo smart speaker, iOS and Android devices and through a web interface. Because of how adaptable the core Alexa software robot is, it can be connected to almost any device, even a physical robot body using IoT development tools such as IFTTT.

5.6 Surgery

STAR is a recent attempt at creating an automated, artificial surgeon. In 2016, STAR performed advanced surgery on live pigs, surpassing the precision and consistency of human surgeons. The robot made use of a a 3D visual tracking system for computer vision and a near-infrared fluorescent imaging system to track the tissue in need of repair[34][35].

The key achievement in this project was essentially how precise autonomous robots have become in their technical ability, as well as being exploited for an obscure, valuable application. It did not have a learning capability or user interface, but for a proof-of-concept STAR displays a shocking degree of potential.

5.7 Vehicle

Waymo is a research and development company owned by Alphabet, Google's holding company. The car is not a ubiquitous robot because it lacks a conversational artificial intelligence, but the technology used to allow it to control itself (see Fig. 17) so effectively are perfect examples of how sensors can be embedded seamlessly within the main device, aiding it appearing truly ubiquitous. A general-purpose artificial intelligence would unlikely be installed on a self-driving car due to safety concerns, but advanced machine learning and the system software could easily be run on a server and accessed remotely by the user. Self-driving cars are an existing example of ubiquitous robot technology being used to effectively perform a task greater than a human could[31].

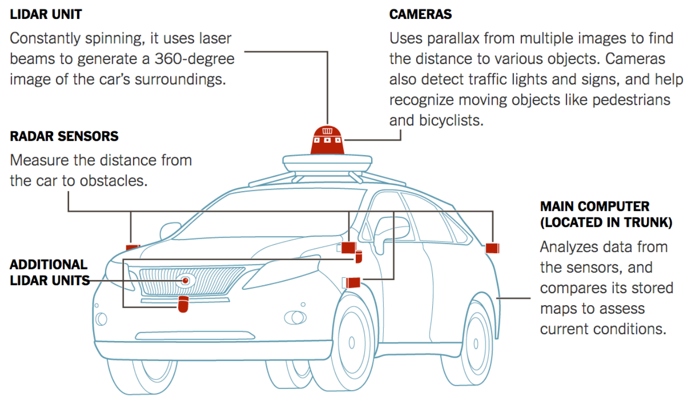


Fig. 17 How the self-driving car understands how to navigate by itself[36].

5.8 Development Tools

A ubiquitous robot requires many different technologies working together seamlessly. Because of this, a variety of development tools would be needed in order to create one.

5.8.1 Machine Learning

Many leading technology companies including Amazon, Google and Microsoft have all released machine learning APIs for developers. A well-known example is the IBM Watson Developer Cloud. It is a collection of APIs which can be used for developing cognitive applications that can retrieve and analyse data, respond to speech and text commands and even make use of computer visual recognition as well as numerous other features[37].

An example of this could be the 'Watson Discovery Service', used for analysing data. It takes in a collection of data (often a JSON array) and can be interacted with using IBM's own query language. The software has been developed so that it can interpret natural human language and gain basic connotations from this. For example, if the data was a series of reviews, the Watson Discovery Service is able to rate the positivity of each review and then feed back the relevant results that the user requested with the query. The Discovery Service API would allow for developers to deploy this analytics system within their own products. An example could be a software robot that uses JavaScript to retrieve comments on a social media post, compile them into a JSON array and then use the Watson API to interpret the data and present an overview of it to the user[38].

Unfortunately, access to the source code of the Watson APIs require a paid subscription. However, there are a variety of attempts at producing an effective open-source rival to proprietary deep learning systems created by corporations, but most have failed due to the complexity of the technology or due to a lack of funding and worthwhile contributors. Google released an open-source machine learning library called TensorFlow in 2015. This allows developers to create deep-learning applications using Python (shown in Fig. 18), which could then be used to form the basis for a software robot's problem solving capability.

TensorFlow is based on the concept of computational graphs; where nodes (known as operations) represent data manipulators such as a sum or an algorithm and each 'stem' represents the flow of data, in the form of a multi-dimensional array. It was initially designed to solely support neural networks, though it can now support any way in which data can be modelled using computational graphs. An initial dataset created using a standard Python class containing the array of data the user wants analysed would be required, before installing the TensorFlow library to make use of its data-manipulation and machine learning functions[39].

Unfortunately, there is no real starting point in developing a general-purpose software robot with TensorFlow yet. It is currently primarily used to develop smaller applications that make use of machine learning for data analysis. However, the advanced machine learning systems such as ones created by Google DeepMind are developed in a similar way to TensorFlow projects, just a lot larger in size and more sophisticated in how data is manipulated and results are responded to.

```python
node1 = tf.constant(3.0, tf.float32)
node2 = tf.constant(4.0) # also tf.float32 implicitly
print(node1, node2)
```

Fig. 18 A snippet of Python code using TensorFlow to create two floating point tensors called 'node1' and 'node2'[39].

An example of an open-source virtual personal assistant called Mycroft was released publicly in 2015. It can interpret natural language smoothly and fetch data and feed it back to the user in a digestible manner, much like Apple's Siri or Amazon's Alexa. Mycroft can run on a Raspberry Pi or any device running Linux[40].

Mycroft's functions are referred to as 'skills' (an example is shown in Fig. 19). It comes with 20 pre-installed skills, but allows for users to develop their own relatively easily, although this would depend on the complexity of the skill. Skills are a collection of Python scripts which are then placed in a new folder in the 'skills' folder within the 'mycroft-core' directory[40].

Skill Name	Example Keyphrase	Function	Output
alarm	"Mycroft, create an alarm for five minutes"	Creates an alarm	"Ok, a new alarm was created on ..."

Fig. 19 An example of a pre-installed 'alarm' skill in Mycroft Core. The Python scripts were quite extensive and in numerous pieces[40].

Due to it being open-source, it has been developed to easily allow for the user to make their own additions to it. Because of this, if a general-purpose artificial intelligence were developed (potentially using a neural network developed using the TensorFlow library) it could use Mycroft as a basis for the user interface for a primitive software robot.

5.8.2 Robot and Embedded Device Operating Systems

The the Ubuntu Core operating system is a stripped down version of Ubuntu Linux which is specifically designed for use in embedded devices such as robots and sensors. It would be an effective operating system for developing a ubiquitous robot, as it can be installed on all the necessary hardware components which would then run the specific program to automate the robot. The specific programs are referred to as 'snaps' and are essentially a compressed file that contain the application as well as all dependencies that then run on the Ubuntu Core[41].

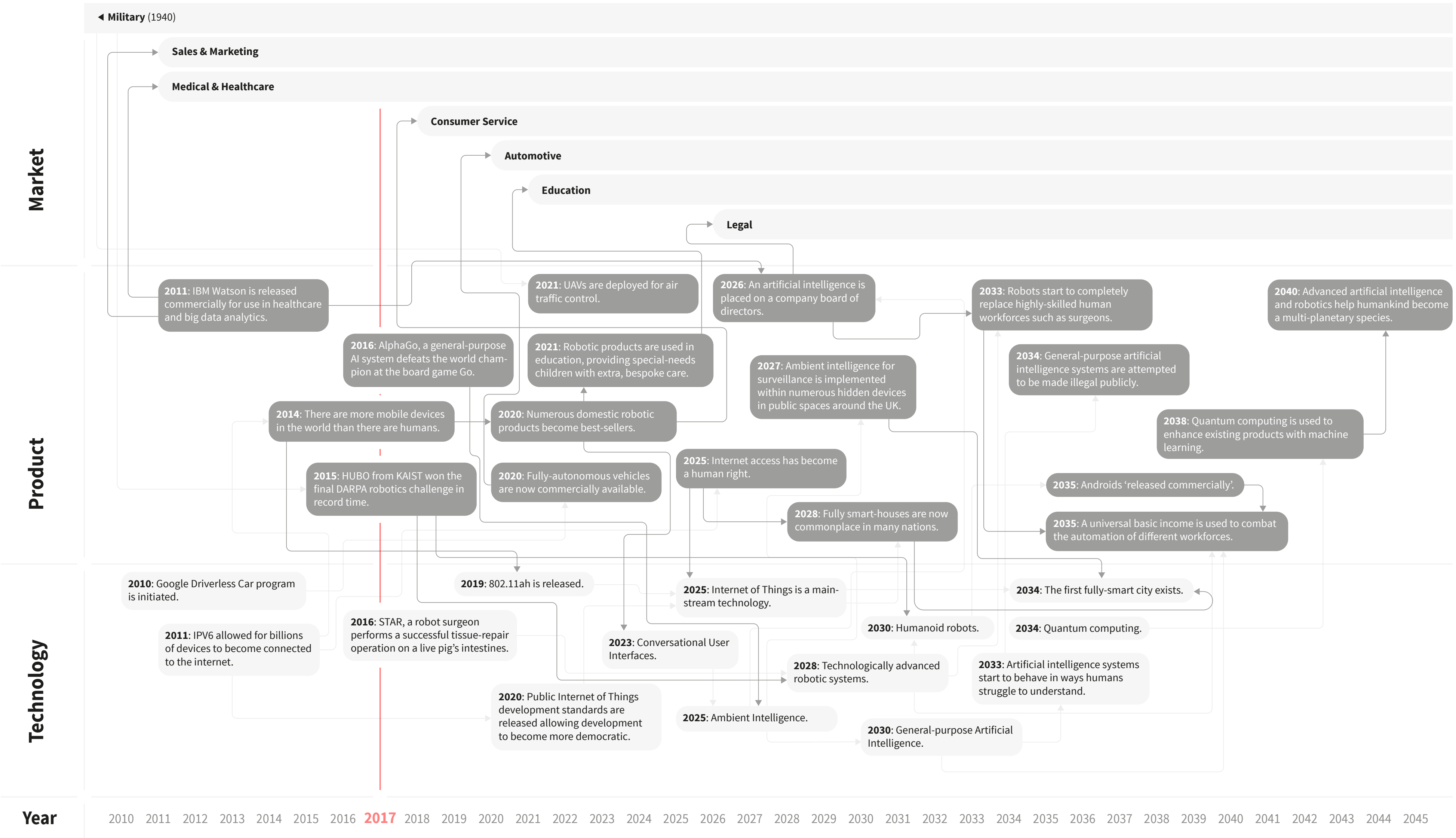
ROS (Robot Operating System) is a group of software frameworks for programming autonomous robots, built on Ubuntu Core. It would be run as a snap on the mobile/embedded robot's processor. The project started at the Stanford Artificial Intelligence laboratory and is open-source and free to use, even for commercial applications. ROS includes a development environment called Gazebo, that simulates the physical world digitally, in order to program a robot in this digital space before executing the commands in the physical world. The supported languages for programming the robots are C++ and Python, which are entered in the command line accompanying the ROS software to not only build robot capabilities but control and test them[42].

As well as providing a space for simulating activities of the robot being designed, the software also includes a space to view embedded device sensor data visually, essentially allowing the developer to see what the robot is able to see. The development community for ROS is very large and have released numerous open-source starting points and pre-developed applications which can be used to finalise a project[42].

5.8.3 Necessary Hardware

Many companies are producing fully developed mobile robots, but most do not encourage active development on the existing hardware. Therefore, the majority of independent robot and Internet of Things developers use Raspberry Pi systems to develop prototypes prior to having bespoke hardware built. The Raspberry Pi machines would have Ubuntu Core installed on them and then run the ROS as a snap which would include the specific robot's application and intelligence system[43].

6.1 Technology Roadmap[45][46][47]



6.2 Supporting Discussion

Advances in machine learning are steady due to it continuing to receive enormous amounts of financial investment from the majority of the largest corporations and governments on a global scale. It is likely that many other devices and even simple objects will have machine learning implemented within them to increase functionality once Internet of Things technology becomes mainstream, which is another technology that is receiving enormous amounts of investment globally.

Once machine learning becomes advanced enough, it will likely be used to attempt to form the basis for a general-purpose artificial intelligence. If this is ever achieved, it will likely transform the face of technology and potentially revolutionise the entire way in which machines function in society. However, a system that is able to think like a human is still quite a distant reality. Advanced embedded robots and ambient intelligence will likely be easier to develop and only make use of elements that mimic human thought process. It is likely that this sort of machine intelligence will be applied to most connected devices, almost definitely including ubiquitous robotics.

Technologically-advanced mobile robots will be a lot slower to develop due to the complexity of the technology and the enormous amount of financial and material investment needed to improve the technology. Ubiquitous robotics will likely mainly make use of their digital presence and access to vast amounts of data to provide functionality with only relatively basic physical bodies for a while.

6.3 Improvements & Progression

At the moment it is difficult to envision an environment in which embedded robots are truly seamless due to a lack of cost-effective hardware and Internet of Things generally still considered an emerging technology.

Since the definition of a ubiquitous robot was coined and outlined in 2004, the nature of embedded robots changed rather dramatically. In modern robotic systems, embedded robots are typically implemented *within* the body of the mobile robot[30], instead of being a separate physical entity. This makes the robot far easier for the user to maintain and better able to respond to different environments without lots of separate parts that increase the chance of damage.

Because the internet itself is still a relatively new technology in society and Internet of Things an even newer concept, there is no existing general standard in place that would allow for a brand and device-neutral ubiquitous space to be developed. Internet connections are seldom provided free of charge and pre-existing environments have not been developed to cater for connected devices, let alone technologically-sophisticated intelligent systems such as a ubiquitous robot.

In order to maximise a robot's functionality, our environments will have to be designed in a more connected manner that is not owned and developed by a for-profit corporation. This would allow for a more democratic and organic evolution and integration of robotic systems within society. The upcoming faster and more powerful internet would allow for connected devices to rapidly transfer larger amounts of data. This would increase the potential of a ubiquitous robot and aid the technology in decreasing in size and becoming more seamless within an environment.

Due to the ubiquitous nature of the technology and the vast potential uses for it, it is likely that ubiquitous robots will be integrated into all sorts of pre-existing computer systems as well as newly developed ones. This will be in order to maximise their productivity through calculated decision making without human intervention and the ability to respond to new environments dynamically[3][6][8].

7.1 Introduction[48]

From my research into artificial intelligence technology for the development of software robots, I found that the main current commercial uses for it involve heavy monitoring and interpretation of personal user data. I even found most mobile robots' ability to record information on the user and feed it back to the manufacturing company impressive, in an alarming and unsettling way. Because of this, I felt that I should consider how the technology could be used to *oppose* certain sorts of potentially unfair surveillance, even if this would just involve a system that solely warns users of how they are being monitored without their consent or knowledge.

The purpose of my product is to protect everyday people in the ever-more connected age; assuming Internet of Things technology has become mainstream and the digital world has become far more implemented within the physical world than it currently is.

Cyber-security is generally perceived as incredibly complex and almost impossible to grasp without extensive knowledge in computing. My product will present this typically confusing data in a very user-friendly, digestible way. It will essentially be a digital personal-security agent and advisor.

Incredibly complex technology has become so commonplace that the vast majority of consumers are not aware of how their devices truly function and their ability to record information about them. As more objects become connected to the internet, it will become increasingly easy for individuals with a lack of advanced knowledge in computing to be exploited by malicious hackers, corrupt governments and greedy corporations. My product will aim to actively stand against this, or at least highlight the need to make the current situation a lot fairer.

7.2 Potential Features

The software robot component of the product will make use of machine learning with the ability to analyse and interpret a device's transmission control protocol, have access to it's network ports and able to detect and remove rootkits.

It will also have a presence within the device's internet browser, where it will be able to detect and block JavaScript beacons, trackers and tags as well as translate dubious corporate terms and conditions sheets and use its artificial intelligence to question potentially risky social media behaviour by the user.

The software robot will store the user's log-in details in a database on a remote server, which will also be where the virtual private network will be located. When the software robot is installed on the user's device it will use the VPN to shield the user's details from internet service providers.

The mobile robot will likely be a drone-like device equipped with RFID tag, bug and drone frequency detectors, meaning that it will be able to follow the user in the physical environment and detect nearby devices that may be tracking the user and invading their privacy using digital technology[49][50].

If the robot is unable to actively prevent some sort of invasion of user privacy, it will simply warn the user of when and how they may be being tracked and advise them on how to avoid or prevent it.

The entire device will be designed in a user-centred manner. It will have a conversational user interface and should be able to be interacted with through gestural control as well with voice commands.

7.3 Incentive & Debate

There are numerous reasons as to why I strongly believe there is a need for this sort of product. As digital technology has progressed, corporations and governments have gained even more control over the public due to being able to access their private data on the internet; from shopping habits to personal relationships. Many people feel that the larger technology companies exploit their customers, who are often not even of aware of how their data is being collected and interpreted to benefit the company.

It was originally said that it was the customer's choice to hand their data and privacy over to a company in return for free services and that this was fair. However, as the world has continued to become more connected, it is becoming almost impossible for a functioning member of society to abstain from using digital services. I believe that this has become totally unfair and there are minimal ways in which a user can truly retain their privacy. I do not think that any company driven by profit and capitalising a market should have this much information on consumers. What worries me most about corporate control, is their drive for increasing turnover. This often means that they will usually do anything to gain money and power that is within the law, often pushing what is within the law to the absolute limit.

Complete trust in the government itself is also a debatable. Many governments heavily rely on funding from corporations, which can then pressure governments into giving them benefits in exploiting their customers. Certain governments also have questionable views on human rights, an example being nations in which it is illegal to be LGBT. The digital environment once allowed people to challenge these laws in private, though with increasing digital surveillance this can be stopped and allow for governments to locate and punish the individuals.

UK Prime Minster Theresa May put the Investigatory Powers Act into action on December 30, 2016[54]. Among other things, this meant that officials from numerous authorities in the United Kingdom were now able to access the public's internet connection records without a warrant. I think that senior individuals in these positions could easily abuse their power for personal reasons. After this act was put through in the UK, the White House voted in favour of a bill that allows for internet service providers to *sell* user data without consent[55]. I consider this an alarming violation of privacy, which just adds to the amount of control large corporations have over their customers.

The final incentive for this product would be for protection against hackers, which is an easier and more obvious target than governments and corporations due to it already being illegal.

I am not stating that my proposed product is an ethical or reasonable response to the current problem, but I feel that the situation is completely unfair and continuing to go in the wrong direction. Because of this, I wanted to design something relatively extreme to emphasise my point. Realistically, I think that there should be a more neutral and fair system in place to combat illegal activity that does not benefit controlling, profit-obsessed corporations or corrupt government officials. Cyber-security using artificial intelligence and robotics for the Internet of Things age is also a new concept, which I hope my product will tackle.

7.4 Deployment Environment

The year in which I feel that this product would be realistically deployed would be between 2025-2030. At this point, Internet of Things technology should have taken off and become mainstream, with entirely smart cities starting to be created, where all kinds of devices are now connected to the internet and able to constantly share user data between each other.

8.1 Software Robot

The software robot will be overarching piece of software that is in control of the entire product, located on a secure server and accessed on the user's device and mobile robot using the internet.

8.1.2 Virtual Personal Assistant

The virtual personal assistant will be how the software robot manifests itself to the user, as a digital presence able to receive and act upon commands. It can be spoken to using natural human language and responds to a wide range of inputs dynamically using its general-purpose machine learning.

8.1.3 Perception Processing

The 'perception processor' is what receives information in different formats, from image to security data and extracts information from it.
It allows for natural language processing, computer vision, image recognition and ability to 'understand' human text.

8.2 Native Application (Device Management System)

The native application installed on the user's device of choice (e.g. a smartphone) is a way in which the software robot can be interacted with directly and the entire product managed by the user. This application is also how the product gains access to a device's security.

8.2.1 Background Processing Analyser

The software robot will interpret the background processing on the user's device and visualise this for the user. The robot will also flag any unexpected behaviour.

8.2.2 Packet Analyser

The transmission control protocol on the device will be visualised and analysed by the software robot, where any unexpected changes will be flagged and brought to the attention of the user.

8.2.3 Network Mapper

The device's network ports will be visualised and analysed by the software robot, where any suspicious behaviour will be flagged and brought to the attention of the user.

8.2.4 Rootkit Remover

Any rootkits on the device will be detected and immediately brought to the attention of the user, before the software robot will attempt to remove the rootkit.

8.2.4 Virtual Private Network

The product will be accompanied by a virtual private network located on the software robot server which is available to the user. This will allow the user to browse the internet yet also mask the device's identity from the internet service provider and other trackers.

8.3 Browser Extension

A browser extension can be downloaded and paired with the native application to give the software robot a presence in the user's preferred internet browser, allowing for it to help the user stay secure online.

8.3.1 JavaScript Trackers

This will detect any JavaScript tags, trackers and beacons. It will inform the user on whom they are being tracked by and block them if wanted.

8.3.2 HTTPS Enforcer

The browser presence will request that every website the user accesses be switched from 'http' to 'https' if the option is available.

8.3.3 Social Media Advisor
The virtual personal assistant will be able to analyse social media behaviour for the user and advise them on the safety of their content.

8.3.4 Terms & Conditions Translation
Long, dubious corporate terms and conditions sheets will be scanned and 'translated' into more digestible language using the software robot's text information extraction ability.

8.3.5 Form Data Corruption
A button that automatically fills out HTML5 forms with skewed data that allows for the user to make use of numerous services without having to enter their actual details. This is a more trivial feature.

8.4 Mobile Robot

At the moment, a mobile robot would seem a little unnecessary as the digital environment is almost entirely contained within an internet browser and on small devices like phones and laptops.

However, assuming Internet of Things technology takes off, digital surveillance will become largely implemented within the physical world. The software robot would not be able to detect or interact with these new connected devices without hacking into them through the user's device, which would be illegal and incredibly difficult. Instead, a mobile robot could be implemented to give the software robot a physical presence that would allow it to advise the user on digital surveillance in the physical world.

8.4.1 RFID Tag, Drone and Bug Detection[50][51][53]
Radio frequencies emitted by bugs and RFID tags will be detected in the connected environment. The robot will use its machine learning and pattern recognition to learn what kind of devices are observing the user. This is certainly the most important feature on the mobile robot, as drones equipped with machine learning are already capable of spying on people, who are generally oblivious of this.

8.4.2 Warning Lights
The robot will use pulsating, coloured lights to warn the user of whether they are in an area that is being spied upon or their privacy being violated.

8.4.4 Flight
The robot will be equipped with a drone-like flight system.

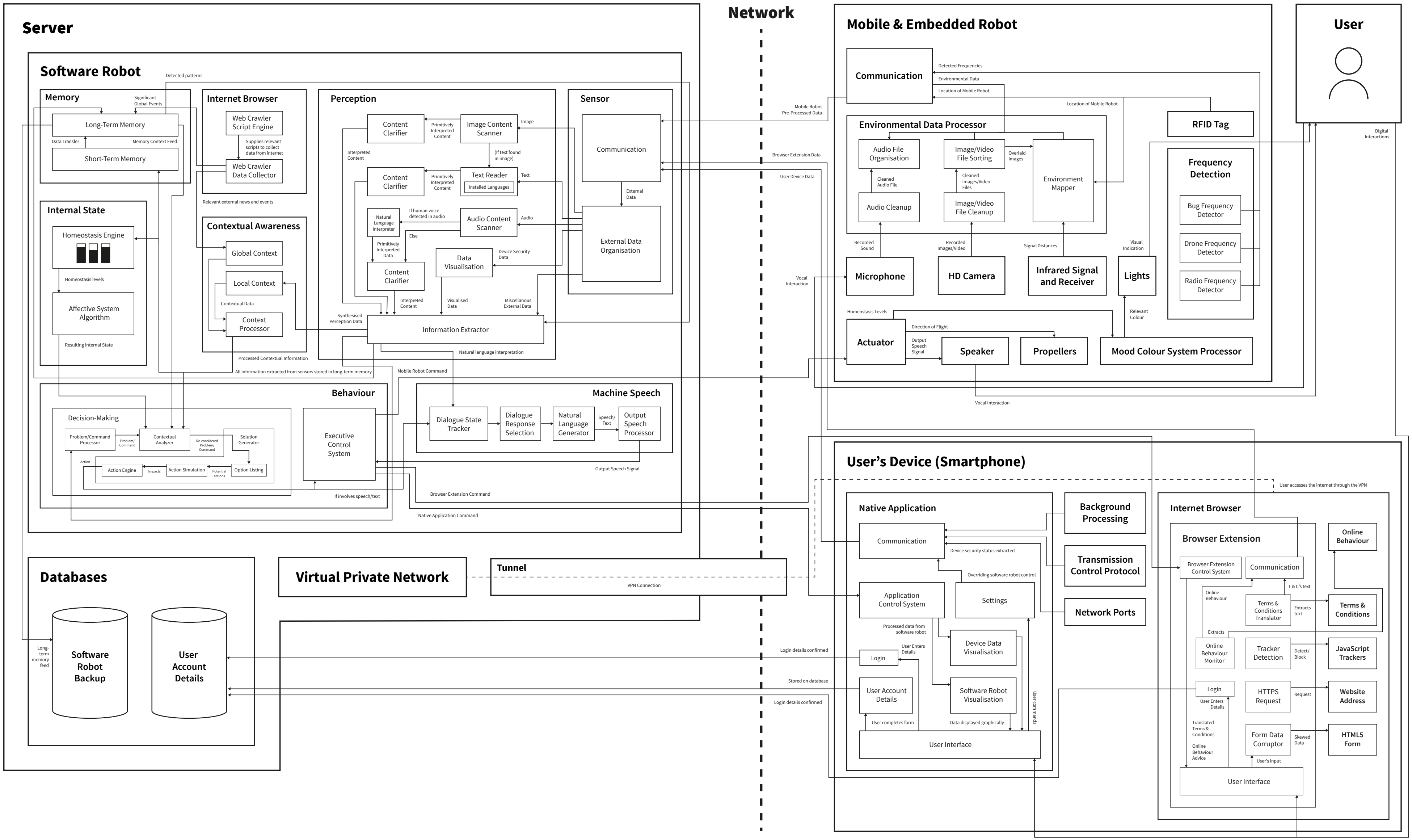
8.4.5 Camera
The robot will be equipped with two 360 degree cameras.

8.4.5 Microphone
It will also be equipped with a microphone to take in audio.

8.4.6 Network Access
Network access is how the software robot will be accessed on the mobile robot as well as make use of a GPS system to aid it in being mobile.

8.4.7 Infrared Signal & Receiver
The mobile robot will combine its camera vision with infrared signalling to map out the environment in which it is placed.

8.4.8 Speaker
The software robot will communicate in human language much like a standard VPA, and the mobile robot will be equipped with a speaker so that it can relay information in the same way.


Server
Software Robot
Detected patterns
Memory
Significant Global Events
Long-Term Memory
Data Transfer
Memory Context Feed
Short-Term Memory
Internet Browser
Web Crawler Script Engine
Supplies relevant scripts to collect data from internet
Web Crawler Data Collector
Relevant external news and events
Perception
Content Clarifier
Primitively Interpreted Content
Image Content Scanner
Image
(If text found in image)
Interpreted Content
Text Reader
Installed Languages
Text
Natural Language Interpreter
If human voice detected in audio
Audio Content Scanner
Audio
Else
Primitively Interpreted Data
Data Visualisation
Device Security Data
Interpreted Content
Visualised Data
Miscellaneous External Data
Synthesised Perception Data
Information Extractor
Natural language interpretation
Sensor
Communication
External Data
External Data Organisation
Internal State
Homeostasis Engine
Homeostasis levels
Affective System Algorithm
Resulting Internal State
Contextual Awareness
Global Context
Local Context
Contextual Data
Context Processor
Processed Contextual Information
All information extracted from sensors stored in long-term memory
Mobile Robot Command
Behaviour
Decision-Making
Problem/Command Processor
Problem/Command
Contextual Analyzer
Re-considered Problem/Command
Solution Generator
Action
Action Engine
Impacts
Action Simulation
Potential Actions
Option Listing
Executive Control System
If involves speech/text
Machine Speech
Dialogue State Tracker
Dialogue Response Selection
Natural Language Generator
Speech/Text
Output Speech Processor
Output Speech Signal
Browser Extension Command
Native Application Command
Databases
Long-term memory feed
Software Robot Backup
User Account Details
Virtual Private Network
Tunnel
VPN Connection
Network
Mobile Robot Pre-Processed Data
Browser Extension Data
User Device Data
Vocal Interaction
Login details confirmed
Stored on database
Login details confirmed
Mobile & Embedded Robot
Communication
Detected Frequencies
Environmental Data
Location of Mobile Robot
Location of Mobile Robot
RFID Tag
Environmental Data Processor
Audio File Organisation
Cleaned Audio File
Audio Cleanup
Image/Video File Sorting
Overlaid Images
Cleaned Images/Video Files
Image/Video File Cleanup
Environment Mapper
Recorded Sound
Recorded Images/Video
Signal Distances
Visual Indication
Microphone
HD Camera
Infrared Signal and Receiver
Lights
Frequency Detection
Bug Frequency Detector
Drone Frequency Detector
Radio Frequency Detector
Homeostasis Levels
Relevant Colour
Direction of Flight
Actuator
Output Speech Signal
Speaker
Propellers
Mood Colour System Processor
Vocal Interaction
User
Digital Interactions
User's Device (Smartphone)
User accesses the internet through the VPN
Native Application
Communication
Device security status extracted
Overriding software robot control
Application Control System
Settings
Processed data from software robot
User Enters Details
Login
Device Data Visualisation
User Account Details
Software Robot Visualisation
User commands
User completes form
Data displayed graphically
User Interface
Background Processing
Transmission Control Protocol
Network Ports
Internet Browser
Browser Extension
Browser Extension Control System
Communication
Online Behaviour
T & C's text
Terms & Conditions Translator
Extracts text
Extracts
Online Behaviour Monitor
Tracker Detection
Detect/Block
Login
User Enters Details
HTTPS Request
Request
Translated Terms & Conditions
Online Behaviour Advice
Form Data Corruptor
Skewed Data
User's input
User Interface
Online Behaviour
Terms & Conditions
JavaScript Trackers
Website Address
HTML5 Form

10.1 Name

I have chosen to name my ubiquitous robot product ‘Espia’. I was influenced by contemporary virtual personal assistant and consumer robotic products such as Siri, Alexa and Kuri which use human-sounding names. I feel that this helps the product feel more natural and therefore trustworthy for the user. The product could also be interacted with more fluidly and naturally if it appeared to have a personality.

Espia is also an anagram for sepia, which is the name of the pigment derived from the shadow-like ink released from cuttlefish as a defence mechanism. In Spanish, Espia means spy and ‘spook’, which is an English slang for an individual involved in espionage.

10.2 Design Justification

The brand had to appear dependable, which I felt could be aided by using shades of blue/violet for the primary brand colour scheme. Blue is often seen as a trustworthy and often corporate colour, which would aid the product in helping the user feel more comfortable in relying on it for digital security. The rest of the design makes use of a colour-based warning system, where green means safe and red means danger. This is the same system that will be used on the mobile robot lights as well as on the data visualisation in the digital application. It is an immediate and visual way for communicating the state of the user’s digital safety.

I wanted the entire design language for the product to appear friendly and playful, in the hope that this would enhance the approachability of the product. I hope that the user would feel disarmed by the calming colours, simple user experience design and friendly, almost *cute* design used for the mobile robot and software robot’s visualisation.

The logo is a condensed illustration of the mobile robot, with two lowercase E’s (for Espia) forming the left and right sides of it.

Main Logo

espia

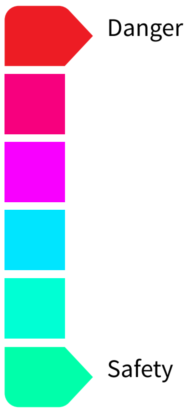
Potential Device Touch Icon

Colour Scheme

Colour 1	Colour 2
C 77	C 23
M 67	M 21
Y 0	Y 0
K 0	K 0
R 103	R 196
G 096	G 193
B 255	B 255
#6760FF	#C4C1FF

Gradient

Warning System



11.1 Design Justification

The primary interface for the entire robot is the Device Management System, which can be accessed as a native application installed on the user's device of choice.

The full interactive prototype can be found here: **https://xd.adobe.com/view/c0074b73-28b4-476c-9ef5-5c71f326a3a0/**

The DMS in this instance is a mobile application, as I felt that this would probably be the most effective device for managing Espia on the go. I made strong use of the minimal pale-blue/white colour scheme, playing heavily with layering objects and modifying their opacity to give the interface a ghostly effect, following the brand identity and subject matter further.

I think that I let myself down when visualising the software robot. I planned to make it more characterful, with a 3D-rendering but could not create the precise effect that I wanted to in time for the deadline. Instead, I chose to implement a more abstract rendering, much like how contemporary VPA's are visualised.

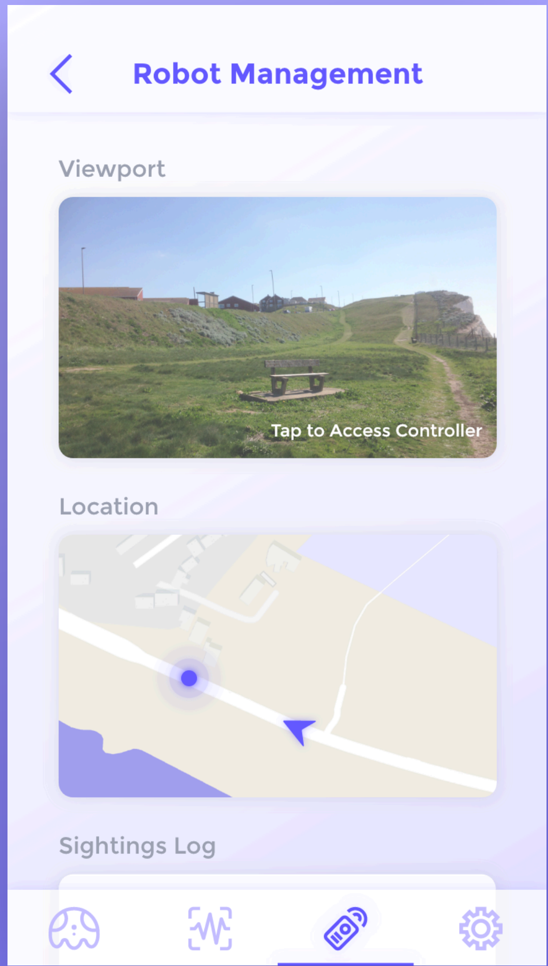
11.2 Selected Mobile Screens

1 - Software Robot Interface

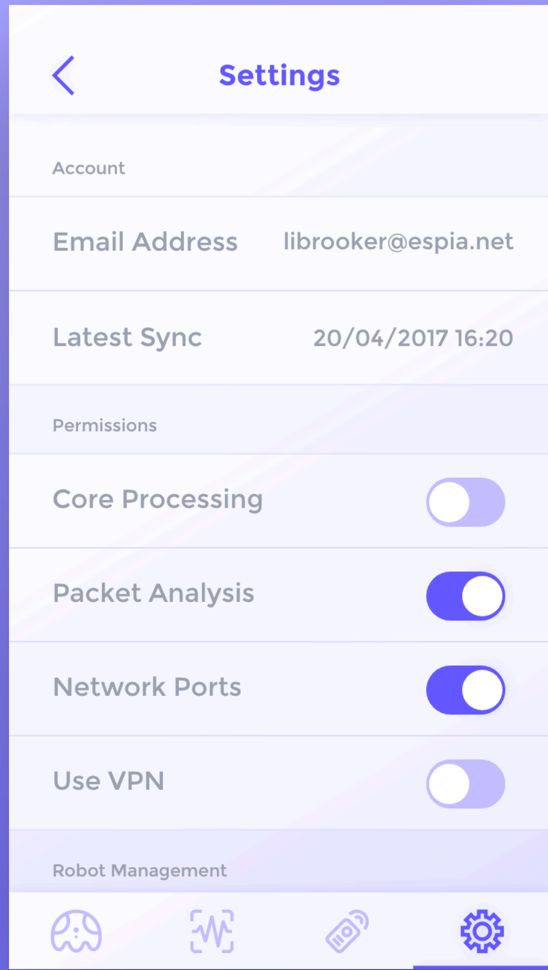
2 - User's Paired Devices

11.2 Selected Mobile Screens Continued

3 - Selected Device Security Monitor

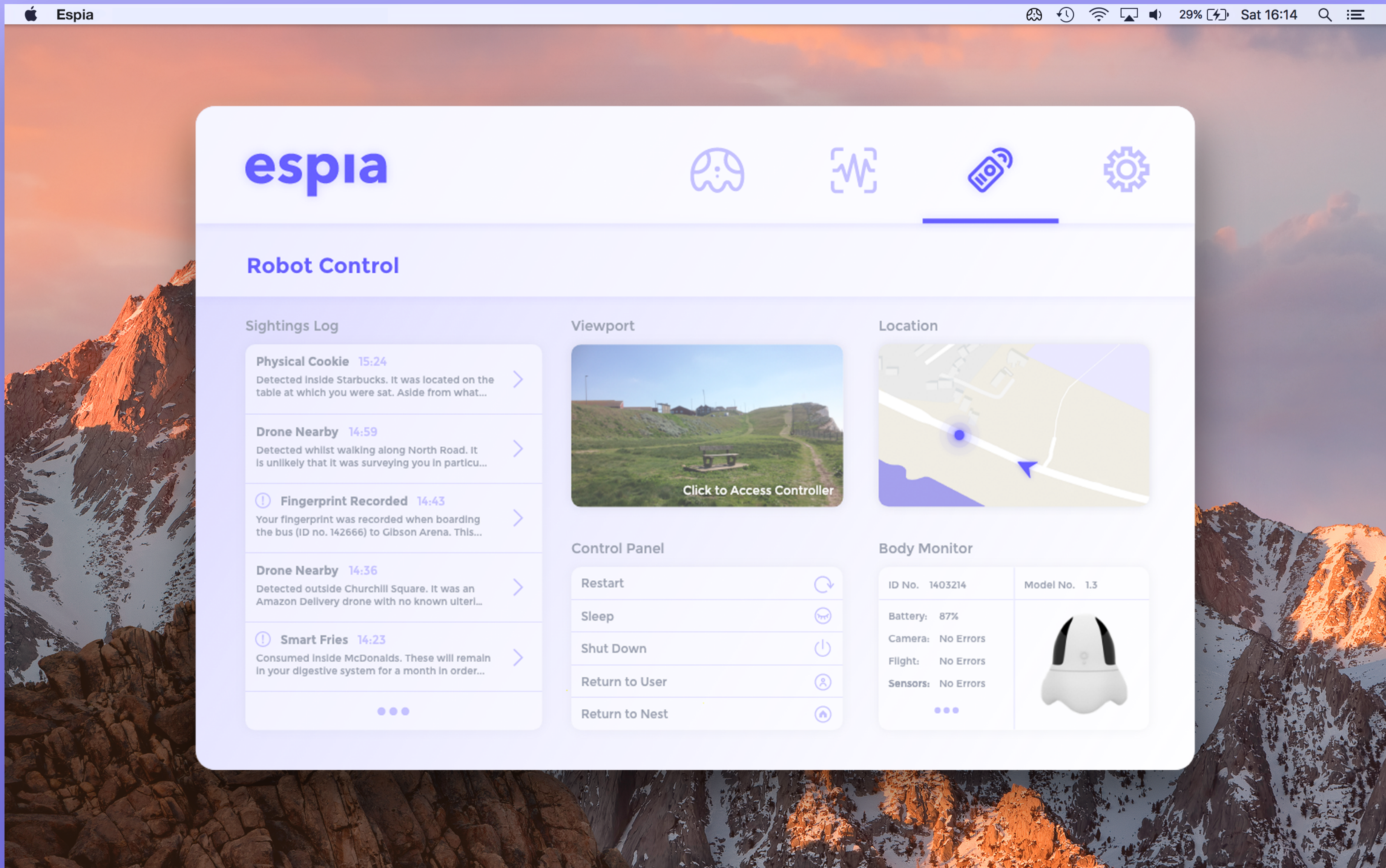


4 - Mobile Robot Management



5 - System Settings

11.3 Example of DMS on larger device



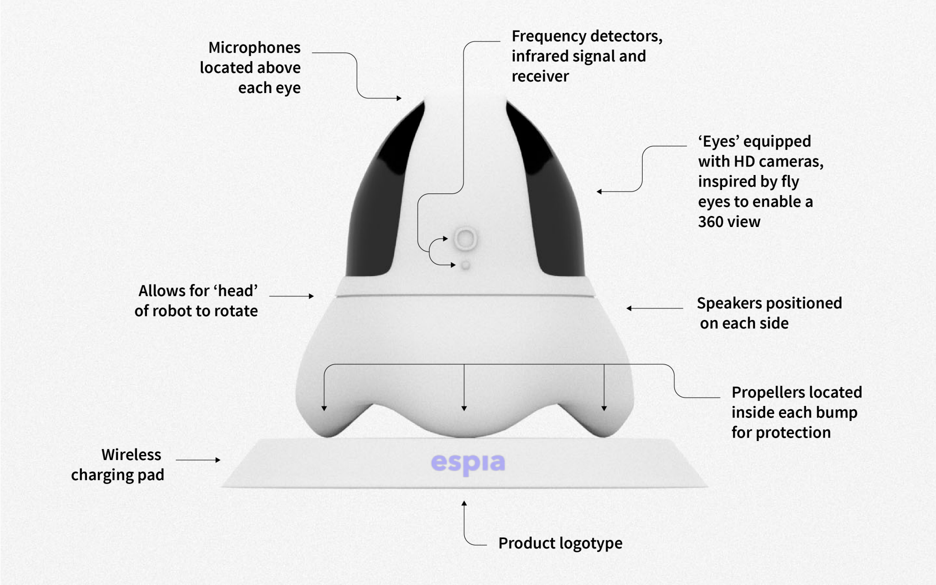
12.1 Design Justification

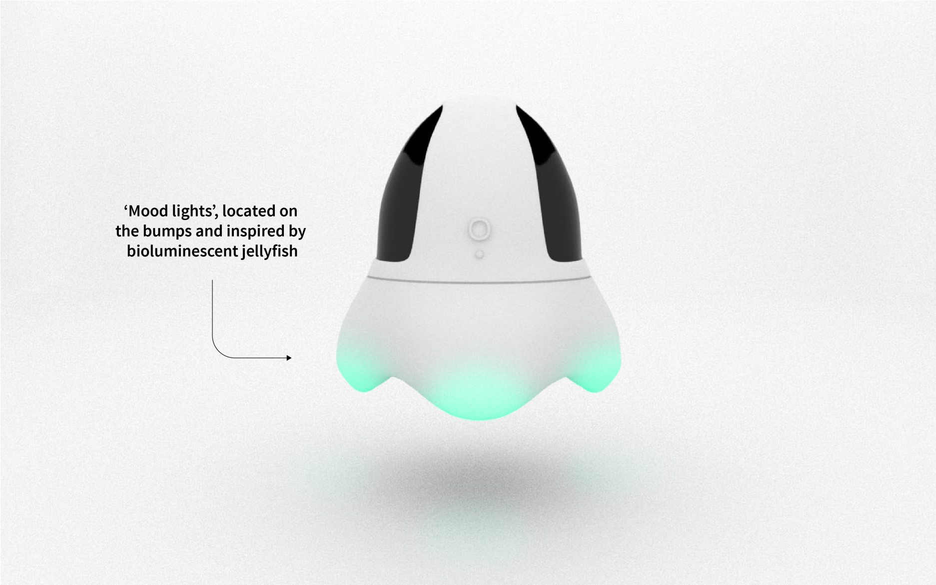
The mobile robot body was primarily inspired by ghosts and cloaks, as well as concept pocket drones that aim to be put on the market in future. The ghost/cloak aesthetic fits the theme of being anti-surveillance and 'cloaking' the user. This also follows the digital design language used in the DMS and branding which make use of soft, organic shapes and a heavy-white colour scheme with alternating opacity to appear ghost-like. I also took inspiration from bioluminescent jellyfish regarding the lighting, and dumbo octopuses for the shape. I felt that the way in which they swim so gracefully could inspire a flying device.

I felt that the hardware had to be minimal and unobtrusive, yet also have some sort of character to enhance usability and encourage the user to attempt to converse and interact with it naturally. I attempted to follow Yves Béhar's *10 Principles for Design in the Age of AI*[57], but think that my robot is potentially too characterful, preventing it from being appropriately discreet. The reason I chose to make it rather characterful was due to current trends in consumer robotics[56] which are thought to be designed in this way to increase trust, as they are still an emerging technology.

From my research into contemporary ubiquitous robotic products, I found that most embedded robots are implemented within the mobile robot. This allows for a more agile and powerful single device, which is more user friendly than the alternative of having the user need to take into account numerous separate sensor devices.

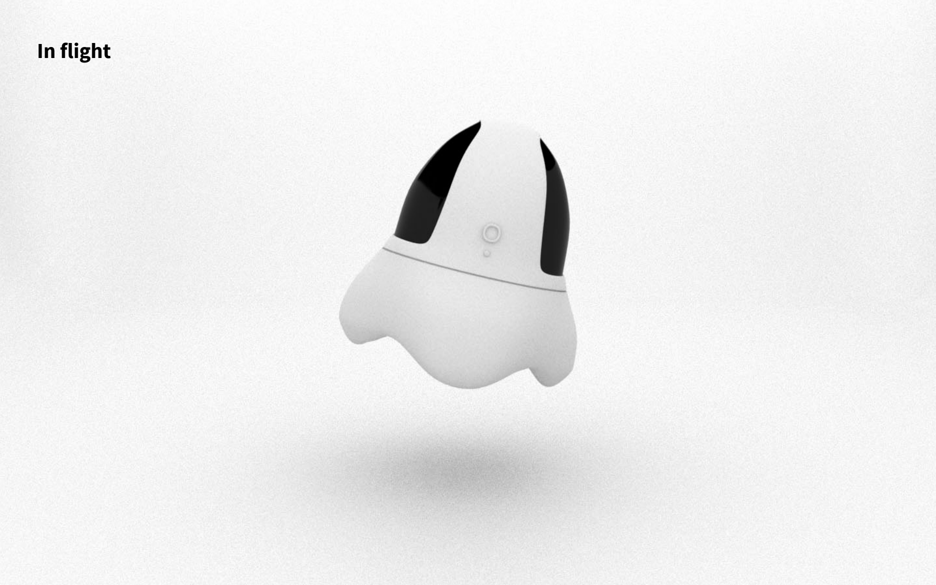
I think that my design for the hardware was successful, a lot more so than my software robot manifestation. Nevertheless, I think that I could have been more ambitious with my use of colour on this product and feel that if I experimented with using more of the Espia brand's violet/blue colour scheme the result would have been more harmonious alongside the digital user interfaces.





Closeup

In flight



Hovering

On charging pad

13.1 Overview

Espia's design was heavily influenced by existing robotics products researched previously such as Kuri and Baxter. However, from a purely technological perspective, it was primarily influenced by the initial research project on ubiquitous robotics, Ubibot. Espia would make use of similar, but smaller, more modern hardware components which would allow for a more compact mobile robot. Espia would be a true ubiquitous robot, with a software robot located on a remote server able to be accessed anywhere with an internet connection.

Espia's software presence would likely be programmed using a later version of TensorFlow or similar framework released by Google DeepMind. This would then be merged with a modified Mycroft VPA as a starting point for the user interface. The hardware could be a Raspberry Pi connected to the necessary flight, lighting and sensor hardware running Ubuntu Core. On this, ROS could be installed which would then be able to access the software robot.

13.2 Behaviour

13.2.1 Drone Detection

Situation: The user is walking down a street. They have an Espia DMS installed on their mobile device, paired with a mobile robot which is hovering by their side. An unknown drone flies over them and may be tracking the user in some way.

Input: The drone frequency is detected by the mobile robot. This data is grouped with the location of the mobile robot, cleaned and relayed to the software robot. The software robot processes the data and extracts information from it. An action is then decided upon.

Response: The software robot decided to notify the user of the event. The software robot then executes a silent, visual notification through the DMS on the user's mobile device stating that a drone has just flown past them. The software robot feeds dynamic homeostasis levels back to the mobile robot, which in return activates neutral lighting.

13.2.2 TCP Communication Monitor

Situation: The user is using their device with the DMS installed, when their TCP communication log begins behaving suspiciously.

Input: The DMS is monitoring all TCP communication. This is sent to the software robot for visualisation and information extraction. The software robot detects the sudden changes in the TCP communication line.

Response: The software robot interprets this as potentially harmful. It is then processed and visualised on the DMS for the user. The software robot activates a spoken notification on the user's device through the DMS. The software robot then attempts to intercept the problem directly.

13.2.3 Internet Browser Tracking

Situation: The user is browsing the internet on their device. They have installed the DMS and paired it with the accompanying browser extension. A website they encounter is making use of JavaScript trackers.

Input: The browser extension detects that this website is using JavaScript trackers, likely for benign user research purposes.

Response: The browser extension notifies the user in the corner of their screen, using a subtle and visual method. The user is able to take note of this and then either dismiss it, or block the tracker.

14.1 Introduction

I have chosen to create a screenplay for my design fiction, though if I had more time to spend on this project I would have aimed to create a short film. The piece still communicates the impacts and story world that I wanted to, but certainly lacks richness and clarity, that I feel I could have added with a more visual medium[58]. It is a primarily diegetic design fiction, which focuses on Espia and its user. I made use of valued dramatic logic because I feel that relationships between people are ultimately what drive the impacts of technology upon society.

The story world is a rather pessimistic one; assuming that the divide between rich and poor has continued to grow in the UK. This divide has allowed for old-fashioned attitudes towards certain lifestyles and differences flourish in working-class neighbourhoods, whilst wealthier individuals remain ignorant of this. Automation of the workforce certainly contributed towards the problem, as well as the government continuing to cut services benefitting disadvantaged individuals and giving corporations more allowances. Espia would not be favoured by corporations due to its active involvement in making surveillance more transparent and fair, which in turn would prevent them from being able to make money from using personal data without consent. I decided for Espia to be created and released as an open-source product by ex-Google DeepMind employees and followers of the free software movement.

I focused on a son with a mother whose poor behaviour on social media in 2017 would later ruin her life. Because of this occurring more and more in future, the general public are a lot more aware of how their digital behaviour and lifestyle is being recorded. This has created a rather paranoid, unnatural and sterile atmosphere. Espia allowed for the main character to live out his life without fear of being judged and spied upon, but it also lead for him to endanger himself with an individual using similar technology for darker reasons.

14.2 Screenplay

ESPIA

INT. BEDROOM - MORNING

LI (16) is in bed and awake, staring uncomfortably up at his wall with his duvet pulled up to his chin. His ‘alarm’ goes off, which involves numerous connected devices all over his room bleating in unison in an attempt to wake him. Multi-cut to each device, which appear to watch him as he is in bed. He sighs and gets up, exiting the bedroom.

INT. KITCHEN - MORNING

LI enters the kitchen and puts some stale slices of bread into a toaster. The toaster greets him by name. He ignores it.

LI’s unhappy-looking MOTHER (40s) is sat at the table watching a video on a device, with a tired facial expression.

VOICE ON VIDEO:

After lengthy debate yesterday, parliament chose to *decline* the request for a universal basic income in response to mass employment, thought to be a result of ever-growing workforce automation…

LI finishes his food and leaves the house, without speaking to MOTHER.

EXT. BUS STATION - DAY

LI stands at the bus shelter with small earbuds in his ear, using a mobile device. The automated bus arrives and he is allowed to board by glancing into a camera making use of facial-recognition.

LI is scrolling down a newsfeed of some sort on his device, where he stumbles upon a news article about a new, open-source ‘ubiquitous robotic product’ known as ‘Espia’ which was created by ex-Google DeepMind employees to combat unethical digital surveillance. LI looks around the bus nervously before saving the link and quickly scrolling onwards.

LI then receives a passive-aggressive notification stating that the individuals who developed Espia may be linked to recent terror attacks. LI looks around again, swallows uncomfortably and shakily un-saves the link.

INT. LIVING ROOM - EVENING

LI returns home to find his MOTHER still on her device at the table in the kitchen, though slightly slumped over and smelling strongly of alcohol.

LI

Mum, really? You said you’d look for a job today, for real this time-

MOTHER cuts him off, slurring.

MOTHER

Don’t you s-speak to m-me like that. There’s n-no jobs around anymore for people, Li.

LI

We’ve been through this. There are.

She ignores him and seems to bring up something completely irrelevant.

MOTHER

All I said was, we don’t want ‘em in our country anymore. We were full. Still are. I’m not racist, I just…

LI

Mum. You and dad did-

MOTHER

-It was ten-fucking-years ago Li! And because of some stupid shit said back ‘en, I can’t live my life now. Everyone was thinkin’ it, but no one had the balls to say it.

LI
(*loudly*)
Mum. You did more than just 'say some things'.

MOTHER
(*shouting*)
You're such a self-righteous little prick!

LI
You know you were blaming the wrong people, right Mum? And Dad deserves to be in prison, both of you did this to yourselves.

MOTHER lunges towards LI in a clumsy attempt to hit him before stopping and looking around at all of the smart devices watching them. MOTHER is trembling with anger, too-much-alcohol and quite possibly fear.

MOTHER
(*whispering and breathing heavily*)
You were one years old Li. You don't know what happened. And if you're so perfect, why didn't you get into one of the good schools they brought back 'en? You w-want to blame me for that too?

LI leaves the room, shaking his head.

MOTHER
(*shouting*)
That's right, run away, you poof!

MOTHER turns back around and starts to cry and sits down. A buzz is heard at the door.

MOTHER
Who… Who's there?

SMART HOUSE
There is a patrol drone at the door. I have been informed that I must let it inside.

MOTHER quickly wipes away her tears before the PATROL DRONE enters the room.

PATROL DRONE
Good evening. A disturbance was detected at this location at 18:53. I am here to check on all individuals involved.

MOTHER
Um, okay, uh, we're fine-

PATROL DRONE
Ms Scarlett Brooker you have been marked as safe. Please can you take me to your son, *Mr Lionel Brooker*?

LI re-enters the kitchen, PATROL DRONE faces him.

LI
Yeah, i’m fine, nothing happened.

LI exits and the PATROL DRONE turns back round to face MOTHER.

PATROL DRONE
This is the third potentially dangerous incident in the last week *Ms Scarlett Brooker*.

MOTHER
I’m sorry, i’m really sorry, it won’t happen again, I promise…

The PATROL DRONE appears to stare back at her, before turning away and leaving the room.

PATROL DRONE
You will be fined £50 for the use of a homophobic slur in such a way. This will be extracted from you in the next 3 days. Good night, *Ms Scarlett Brooker.*

The PATROL DRONE exits and MOTHER holds her head in her hands, beginning to sob. A targeted advertisement for *Alcoholics Anonymous* appears on her device, and she

CONTINUED:

slumps over onto the kitchen table, crying.

INT. BUS - AFTERNOON

The next day LI is travelling on the bus on his way home again, scrolling through his newsfeed. He sees the article about Espia on his newsfeed again, along with spammed comments from an anonymous account with a link to a supposed download. Other comments state *‘holy shit, this is legit’* and *‘everyone get it before it gets taken down!!’*. LI looks around at the bus and back at his screen, surprised and silently excited.

AUTONOMOUS BUS
Current stop: Whitehawk Library…

LI quickly gets up and exits the bus.

INT. LIBRARY - AFTERNOON

LI swiftly enters the library and walks up to a desktop device, sitting down and scanning his face with the camera to gain access to it. He rushes to to download the Espia components, but finds that they are all packaged separately and disguised as more benign objects. LI downloads each one at a different computer each time and sends them off to the appropriate 3D printer[60], as well as then linking his mobile device to install the software robot onto it. He is shaking with excitement as well as with fear of being caught, but fortunately for him the old library is completely empty. Espia awakens on his mobile device. LI swallows, his heart beating fast. A voice speaks from his mobile device.

ESPIA

Hello. I see you have chosen to give me a body- please assemble this in a more private location. I also must hide now. Goodbye.

LI frowns at his mobile device screen, confused as it appears to turn itself off. Another robot moves in behind him, making him jump.

LIBRARY ROBOT

Sorry if I startled you. You have been noted as behaving suspiciously, though you have not been accused of anything yet. I am merely here to inspect what you have been printing.

LI nods and shows the LIBRARY ROBOT the downloaded components, worried.

LIBRARY ROBOT

CONTINUED:

This all looks fine to me. Thank you for using our services this evening *Mr Lionel Brooker*. Goodbye.

LI looks even more confused, thinking that Espia would have been detected and violated the library's 3D printing rules if caught. He breathes a sigh of relief and leaves.

INT. LIVING ROOM - NIGHT

LI quietly enters his living room, and creeps up to the master device, using it to turn off every smart device in the house.

INT. BEDROOM - NIGHT

LI empties out the freshly printed Espia components onto his bed. He starts assembling Espia's body, using the downloaded components and technical parts that were gathered earlier. He is guided by the software robot, which is accessed on his mobile device.

ESPIA

I believe I am ready to pair with the body now, thank you.

LI

And you just do that by yourself?

ESPIA
Yes! Just like this.

Lights glow through the tips at the bottom of the device in LI's hands, and the propellers allow it to rise up into the air.

LI
Oh my god…

ESPIA
Now we can speak properly! I am Espia, a virtual personal assistant designed to keep you safe, both in the physical and digital worlds. Fortunately, you have also given me a body, which is usually the hardest part to get hold of.

The tips on the device glow a warm green, indicating happiness. LI watches in awe.

ESPIA
Let's begin the setup. What is your name?

LI
Uh, my name is Lionel, but you can call me Li.

ESPIA
Li, certainly…

FADE TO BLACK.

INT. KITCHEN - MORNING

MOTHER is scrolling through the master device, where she finds out that the smart home was turned off last night. A notification marks this as suspicious. She frowns, before LI walks in followed by a small, drone-like device. He opens the fridge.

MOTHER
(pointing at ESPIA)
What's that thing?

LI
Um, just some toy. I made it myself.

MOTHER
Oh, uh, cool. Sorry I called you a
(whispering)
poof the other day. You're not one, are you? Yeah, I know you're not one.

MOTHER looks a little worried.

MOTHER
It's just the clothes you wear… Just the modern style though, ain't it?

LI
Of course mum.

It has been a few days since LI downloaded Espia. He has also been able to feel free online and use the internet to meet other LGBT people and be himself on social media, whilst hiding this behaviour from his mother, other college students and corporations.

INT. BUS - MORNING

LI walks onto the bus to college, looking content for the first time in a while. He sits down and begins freely conversing with some people over a messaging application on his mobile device. He laughs. Cut to ESPIA's body poking out from one of his pockets.

INT. CAFE - DAY

LI is sat in a cafe on his mobile device again. ESPIA notifies him of the 'physical cookies' being collected on him by the cafe company on the smart table he is sat at. He dismisses the notification, but looks around uncomfortably before leaving.

INT. BUS EVENING

LI is sat back on the bus, where he is about to make a post on social media, that would inadvertently reveal his sexuality. ESPIA mentions that this could easily be discovered by his mother. LI chooses not to post it.

INT. BEDROOM - NIGHT

LI is in bed video-chatting with two new INTERNET FRIENDS.

INTERNET FRIEND #1

Okay, I just don't get- why you haven't told your mum yet, it's 2027, who the fuck isn't even gay these days? My dad said that he's never even met a homophobe- and he's like 60.

Both INTERNET FRIENDS laugh, as well as LI, who laughs along awkwardly.

LI

Hey, leave it. It wouldn't make any sense to you.

INTERNET FRIEND #2

Try us.

LI

She's just… uneducated. People like us got left behind out here. The media, government and you lot act like its all okay to be yourself, but really, out here, its much further back than that. The government gave up with our schools, as well as everything else for the poor if it didn't make them money somehow.

INTERNET FRIEND #1
Hmmmm… I don't know Li. I really don't think you need that weird little robot thing, you're being a bit of a pu-

LI
I'm not a pussy. My mum would literally cut me off. Remember the EDL? My parents were part of that whole thing. That's the kind of people they are. Shit like that still exists, just as bad. Its not part of history for all of us.

INTERNET FRIEND #2
What the fuck Li…

LI
That's right. Night guys.

LI leaves the chat.

INTERNET FRIEND #1
Okay, *now* I believe that he's been too scared to have a wank before.

INTERNET FRIEND #2
That's not funny Seb.

Cut from the chat screen to LI in bed, restlessly looking around his room at all of

CONTINUED:

the connected devices.

LI
So there's really no chance my mum or any ISP's can see what i'm looking at now and aren't going to tell every company I ever want to work for?

ESPIA
No, Li. You are using the Espia VPN and I have blocked the JavaScript trackers. You don't have access to anything illegal, but you're free to explore the internet without a company or your mother watching over your shoulder.

LI
Right. Well in that case… some privacy please?

ESPIA
Certainly, Li. Have a *good* night.

LI
Did you just… Never mind.

LI looks around, searching for '*www.por*' before the scene cuts.

INT. BUS - MORNING

LI is now confidently using an online dating application, rapidly swiping through other users on his way to college. There are numerous previous matches, implying that he is now an experienced user and even more time has passed since he first downloaded ESPIA. He matches with a user named Lars. They send flirtatious messages to each other and Lars asks to meet LI. ESPIA intervenes.

ESPIA
Are you sure that meeting with Lars is a good idea so soon?

LI
It's been fine so far, why would Lars be any different?

ESPIA
I could not find any other online presence. I find this suspicious.

LI
(frustratedly)
Well maybe he's like me and has another Espia? I'm not a kid, I've got this. Leave me alone.

He dismisses ESPIA and returns to the dating application, smiling at the photo of Lars.

INT. BEDROOM - UNKNOWN

OWEN (early 30s) is overweight, balding and sat at a desk in a darkened room. He is eating Doritos and on a rather distasteful forum known as 4Chan.

Camera pans around his messy room, which is littered with pieces of dismantled hardware and posters of young girls drawn in the Japanese manga illustration style.

Cut to shoulder-view of OWEN's multiple monitors. On one he is on the deep web viewing poor-quality footage of people being tortured. At the same time, he is sharing them with people on the forum, jeering at the victims and making memes about them.

He then looks over to a different monitor on the forum titled 'My Plan', written by himself. He outlined that this will involve kidnapping a boy and proceeding to inject them with enough hormones over time to have them become a feminine sex slave[59]. Other users refer to this post as 'too far' and 'obviously bullshit'. One user questions why not just kidnap a girl. OWEN types a sinister response.

Cut to closeup of '*This is the fun way. Besides, young faggots are easy to capture*' being typed on the screen.

He then turns to a different monitor which is displaying a fake dating profile, under the name of 'Lars'. He writes a response to LI's last message on where they will meet.

Cut to OWEN's face smiling blankly, lit up by the bright monitor in the darkened room.

EXT. STREET - EVENING

LI is walking down a dark street, checking his mobile device at the same time and looking confused. ESPIA is hovering by him, its tips glowing a deep red for danger.

ESPIA
Li, I am still very concerned about this meeting. I am also concerned about the *lack* of surveillance technology in this area. There are no security cameras or devices tracking you.

LI
This is a dodgy area. To be honest I'm having second thoughts, I'll head back home instead.

ESPIA
Li, I have detected some frequencies nearby which I feel may be able to detect me. You must be careful.

LI
What? Where? How am I supposed to stay careful, Espia?

ESPIA's body then abruptly flies away.

LI
(shouting)
Espia?!

ESPIA then speaks through LI's mobile device.

ESPIA
Lars is not who this person says they are. You are in immediate danger Li.

LI
(panicking)
How do you know this?!

LI is then hit over the head by an unknown assailant and knocked out. The assailant stamps on LI's mobile device, breaking it. Camera rises to reveal the assailant is OWEN wearing a balaclava.

INT. BASEMENT - NIGHT

LI wakes up naked and inside a makeshift cage, to OWEN laughing.

OWEN
(Jeering)
She's awake!

LI attempts to scream, but his mouth is duck-taped and his limbs tied with rope.

OWEN
No one's going to hear you. Don't bother. *(Laughing)* Are you already crying? You're a real little bitch aren't you? Looks like you're ready for part one of your little transition.

OWEN pulls out a full syringe. LI's eyes widen and he begins to panic even more.

OWEN
Know what this is? I'd be surprised if *you* don't. Its oestrogen. I'm going to have so much fun with you-

OWEN is interrupted by police sirens and a door upstairs being smashed open. OWEN's face switches from a confident sneer to worried. The basement door is burst open.

POLICE OFFICER #1
You are under arrest! Put the weapon on the ground and put your hands in the air…

The POLICE OFFICER's words begin to fade out as OWEN looks at LI sobbing on the floor, the look of disbelief and confusion turning to anger, inwardly questioning how this boy had outsmarted him.

INT. POLICE STATION - MORNING

LI is sitting down, still in shock with a blanket wrapped round him. He is being spoken to by a police officer, but not paying full attention due to still being in a daze.

POLICE OFFICER #2
We don't know who sent us the details, it was one of the strangest reports of a crime I've ever seen. I honestly thought it was a weird joke at first.

LI
…What happened?

POLICE OFFICER #2
We were sent a video of you being hit over the head and abducted by someone. There was an accompanying message that looked like it had been written by a bot. Do you own one of those new security robot things?

LI
Uh… Yeah, I do.

POLICE OFFICER #2
Well it looks like that was what reported your disappearance so quickly. It also must have tracked you in the car, as we were even sent a map with the precise location of where you were. Essentially the whole abduction was recorded from afar.

LI sat looking tired yet perplexed.

POLICE OFFICER #2
Anyway, we couldn’t find any bot. Would you like a hot drink of something? We called your mum, she’s on her way.

LI
…Can I get a breath of fresh air?

POLICE OFFICER #2
Uh, sure. The exit’s just to the left down that corridor.

LI
Thanks.

LI exits, breathing heavily, still not having processed the event. He then notices a small object flying over the police station toward him. He frowns up at whatever it is. His eyes widen as he realises it is ESPIA.

LI
…Espia?

ESPIA
Good morning, Li.

LI grabs ESPIA’s body and holds it close.

LI
(confused)
But you… you flew off?

ESPIA
I purposefully evaded the individual so that they could not damage me whilst I recorded the incident. I then called the emergency services. We were lucky Li. It could have gone a lot worse for you.

LI
You… You saved my life. Thank you…

LI begins to tear up.

ESPIA
It is just my job Li. You are welcome.

Long-shot of a silhouette of LI holding ESPIA close to his chest on the police station porch, against the sunrise.

FADE OUT.

Assuming that technology will continue to advance at the rate it is now, I think ubiquitous robotics will definitely become mainstream, to the point that it seems to disappear through being integrated within almost all other devices to enhance their functionality enormously.

However, I was disappointed by my research into current attempts at creating an 'artificial intelligence', which do not behave in the way that media hype or entertainment would lead one to believe. Even Google DeepMind's AlphaGo, which is arguably the most advanced general-purpose artificial intelligence system on the planet, is incredibly slow and extremely limited in scope.

Unfortunately, advanced machine learning with the ability to analyse and manipulate data is being heavily invested in and seems like more of a reality than a human-like artificial intelligence. This sort of system is a lot less glamorous, far from passing the Turing Test and yet still able to replace numerous human workforces on a global scale.

Espia, my exploitation of ubiquitous robotics, was incredibly idealistic and naive. The way in which a public product would be able to converse naturally and thoughtfully using a general-purpose artificial intelligence system is certainly a lot further away than just 15 years to me.

However, Espia's ability to detect and visualise surveillance and digital security invasion on the other hand, was a lot more realistic. This became especially apparent to me when looking at how the relevant hardware is becoming smaller and more likely able to be packaged within a smaller device. The seemingly-advanced digital security software that I specified in the Key Features section of this report all currently exist and are even free to use. I was shocked at how appalling their user-interface and experience design was though, which lead me to think that a business opportunity could lie in making digital security and privacy software more approachable and open to those not adept at computing. A reason as to why this sort of software has been largely ignored by the mainstream could be because the dangers of surveillance are still relatively new to society. The online world, to many, still seems like a free and open space. Like in my Design Fiction, I think that the repercussions of questionable online behaviour will become more apparent in future.

If a more primitive machine learning system could be implemented to analyse the raw device and browser security data, then a primitive Espia software robot could be developed. The least-realistic aspect of the ubiquitous robot was its ability to converse with the user and make decisions and actions so confidently without human input. Ambient intelligence seems like a more achievable and appropriate goal that would work as a more realistic basis for the software robot component of a ubiquitous robot system.

I believe that my initial aims were successful. I learnt a lot about an emerging technology that has enormous potential, which included both negative and positive impacts of it. I truly enjoyed researching ubiquitous robotics and then designing my own product. I did feel that I was affected negatively by my research into unethical surveillance, which quickly turned to having to research contemporary social and political issues such as online behaviour, corporate control and workforce automation. I would have rather left these topics from my Design Fiction, but this was unavoidable as they were so heavily related to my product.

I think that ubiquitous robotics could be effectively merged with human augmentation in future. This would make use of more cost and resource-effective nanotechnology as opposed to clunky, mobile and embedded robots. This would seek to enhance human ability instead of replace it, which is seen as a key potential solution to the debate against how machines are replacing humans.

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