



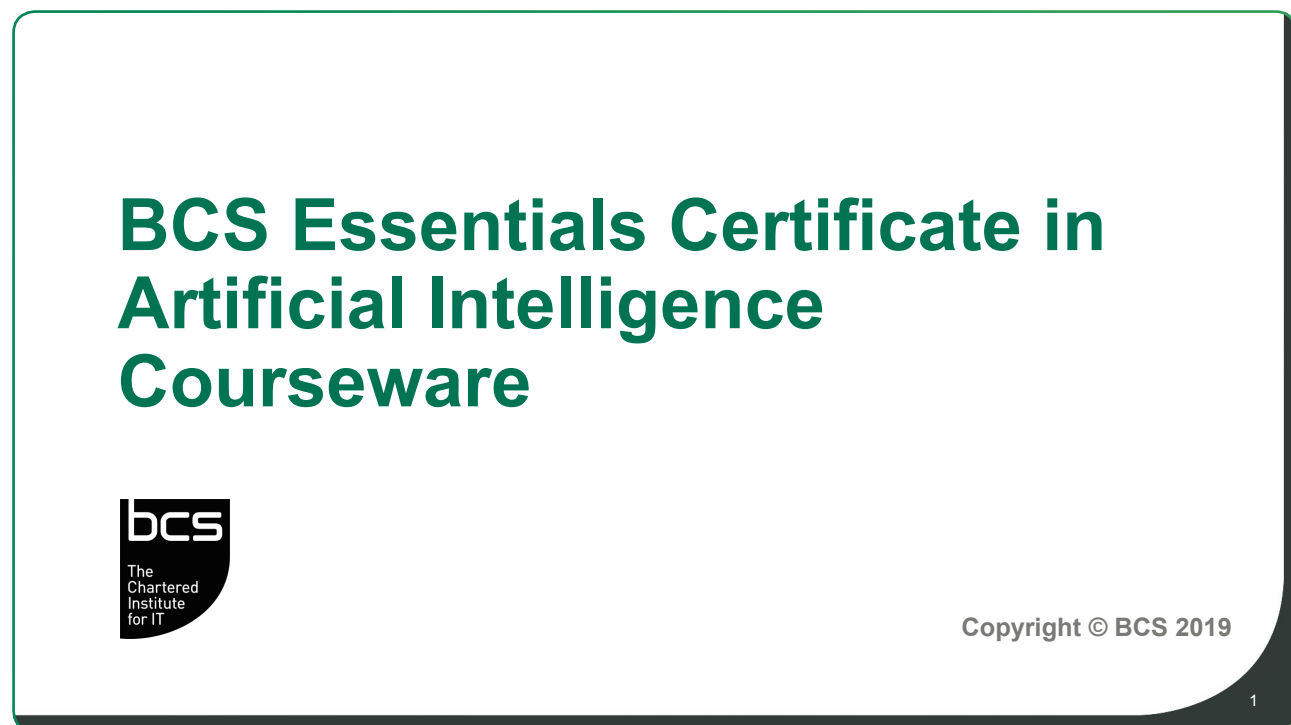
BCS ESSENTIALS CERTIFICATE IN ARTIFICIAL INTELLIGENCE COURSEWARE



TUTOR MANUAL

BCS Essentials Certificate in Artificial Intelligence Courseware

Slide 1 – Title slide



Welcome

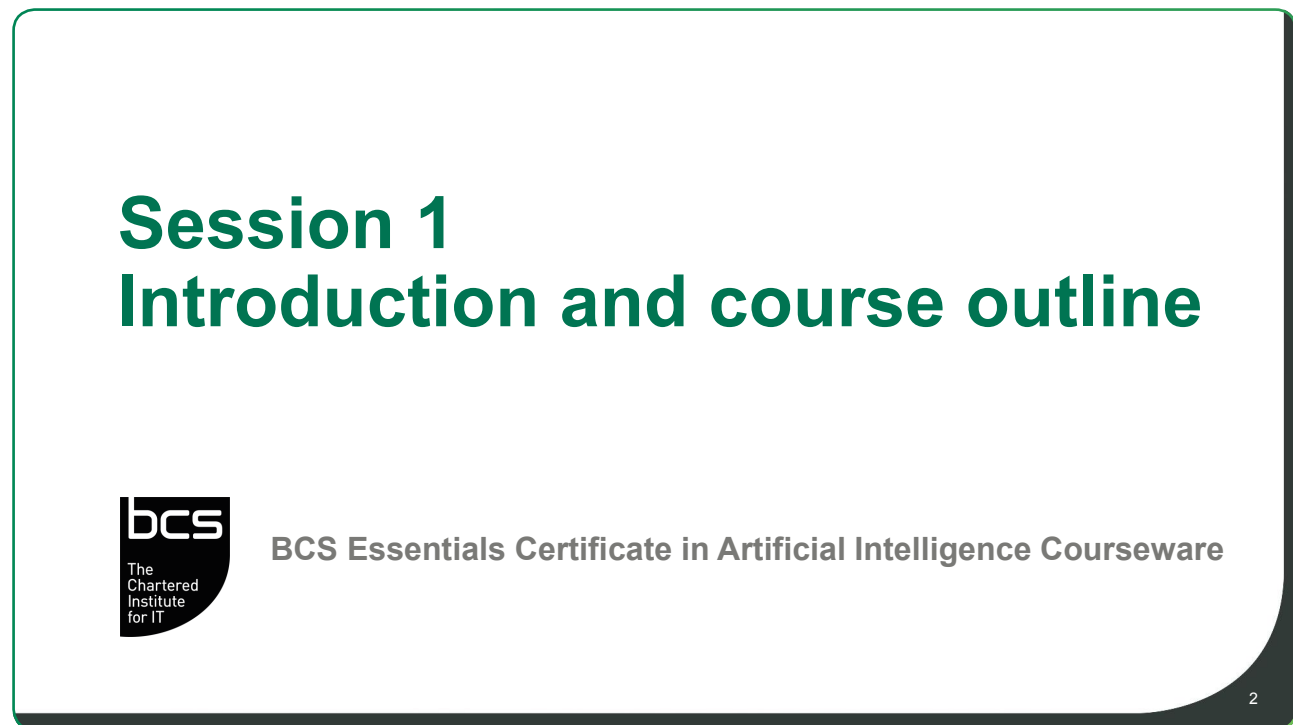
Greet course delegates as they enter and ensure that they are comfortable and ready to commence their learning experience.

Try to start on time as there is a lot to get through and in larger groups there may well be extended interaction making the course potentially longer.

Session 1

Introduction and course outline

Slide 2 – Title slide



Provides delegates with an outline of the course content.

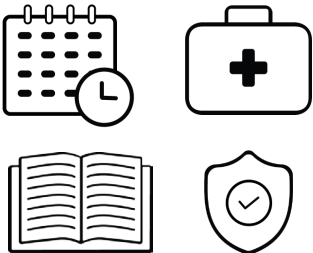
This gives the tutor an opportunity to find out about the delegates' roles, organisations and experience of AI.

To inform the delegates of the examination structure and what to expect in the end-of-course examination.

Slide 3 – Domestics

Domestics

- Start and end times
- Breaks and lunch
- Health and safety
- Facilities
- Smoking
- Materials



3

Explain the ground rules for the course.


Remember to have checked if there is likely to be a fire alarm test and where the exit points are from the building.

Also explain the course materials. The delegate folder contains printouts of the slide set with ample room beneath each slide for note taking.

Slide 4 – Introductions

Introductions

- Name
- Organisation
- Title / Role
- Experience
- Your objectives:
 - for the day
 - for beyond



4

Get the delegates to introduce themselves individually.

Ask questions about their background and experience. Understanding these things makes it easier to bring out these experiences during the course.

Also, try to understand the reasons for the delegate attending the course as this can vary and affect the responsiveness of the delegates.

Get them to ask what their DNA is and what could they teach an AI system.

Slide 5 – Course timetable (Example)

Course timetable (Example)

Time	Duration (mins)	Activity
09:00–09:30	30	Introduction and arrangements
09:30–10:30	60	Artificial and human intelligence – an introduction and history
10:30–10:45	15	Exercise One: Opportunities for an AI system
10:45–11:00	15	MORNING BREAK
11:00–12:00	60	Examples of AI – benefits, challenges and risks
12:00–12:45	45	LUNCH
12:45–13:30	45	An introduction to Machine Learning – part 1
13:30–14:15	45	An introduction to Machine Learning – part 2
14:15–14:30	15	Exercise Two: Maturity and funding of an AI system
14:30–15:15	45	The future of artificial intelligence – human and machine together
15:15–15:30	15	AFTERNOON BREAK
15:30–15:45	15	Exercise Three: Re-imagining the future opportunities for AI and human systems
15:45–16:00	15	Conclusion
16:00–16:15	15	Examination practice and preparation
16:15–17:00	45	MOCK EXAM / EXAM

5

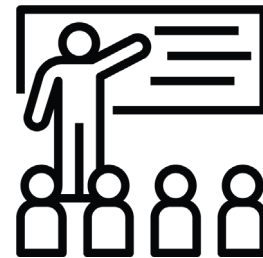
Explain the high-level view of the timetable and the structure and approach that will be taken. It should be considered a guide.

If possible, try to stick to the timings as there is a lot to get through.

Slide 6 – Course structure and approach

Course structure and approach

- Power-point presentation
 - Lecture
 - Hand-outs
- Discussion
 - Interaction
- Exercises
 - Feedback
- Test questions
 - Review



6

Explain that there should be interaction. This is not a lecture.

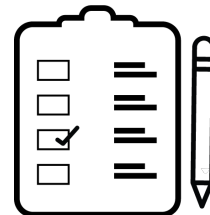
Encourage the delegates to share their experiences of AI but be aware that some may wish to share too much and may be disruptive. Use your judgement and experience as a trainer to control the day.

The course contains lots of links to be explored after the course and also an extensive reading list for those that seek more knowledge of AI.

Slide 7 – Examination format

Examination format

- A 30-minute 'closed book', multiple-choice paper consisting of 20 questions
- Invigilated by the course tutor (time checks and finished paper down)
- Registration on BCS website required to access results
- Results available normally within a week or two
- Pencils



7

Explain the format of the BCS AI Essentials Exam. Explain that as the Invigilator you will represent BCS and will control all aspects of the examination.

Don't forget to acquire some pencils before the exam.

Post course: return the exam material and answer papers to BCS as normal.

Do not allow delegates to copy or remove exam materials from the room.

Slide 8 – What's in it for me?

What's in it for me?

- Artificial and human intelligence – an introduction and history
 - Exercise One: Opportunities for an AI system
- Examples of AI – benefits, challenges and risks
- An introduction to Machine Learning
 - Exercise Two: Maturity and funding of an AI system
- The future of artificial intelligence – human and machine together
 - Exercise Three: Re-imagining the future opportunities for AI and human systems

8

These are the main topic areas and there will be three exercises during the course to reinforce learning objectives, get the delegates to think and to aid discussion.

Slide 9 – Journey home – so what?

Journey home – so what?

- The Fourth Industrial Revolution will make us re-imagine every aspect of life.
- It is about 'learning from experience' – Building Intelligent Entities
- It is NOT a Silver Bullet.
- Machine Learning needs good quality DATA and good algorithms.

9

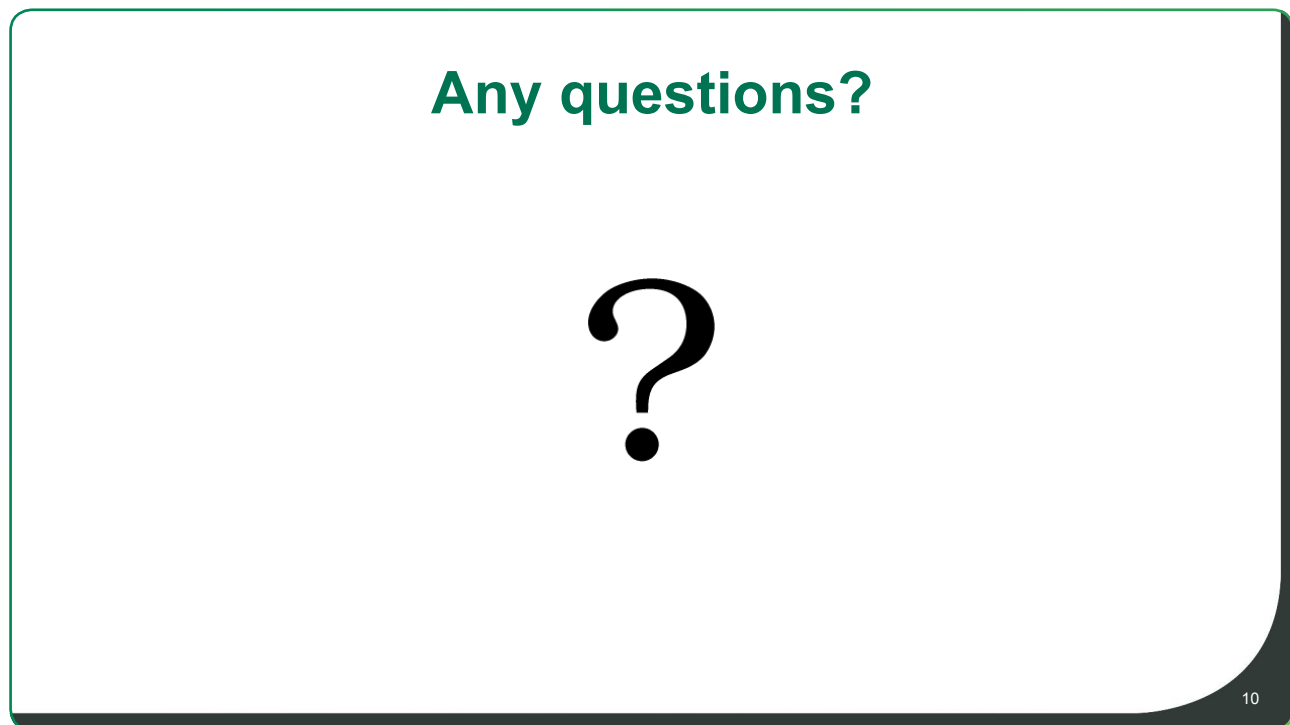
On the journey home after the course these bullet points should be the four key areas that the delegate reflect on.

In fact, they can start reflecting on them now and during the course.

This slide is repeated at the end of the course. The course is not intended as a one-off event.

We hope to have sparked an interest in delegates to explore AI further in their work and personal lives.

Slide 10 – Any questions?



This is an opportunity to check that both you and the delegates understand the format of the rest of the day and identify if there are any specific aspects of AI that the delegates want to explore further during and after the course.

Session 2

Artificial and human intelligence – *an introduction and history*

Slide 11 – Title slide



This section sets the scene in terms of an introduction to AI: what AI is; where AI has come from historically and how it compares to human intelligence.

This is the first main section of the course and we will cover a broad range of topics during the day.

Explain what is going to be covered in this section:

- an Introduction to AI;
- the history of AI;
- what 'Learning from Experience' actually means.

Slide 12 – Human and artificial intelligence (1/2)

Human and artificial intelligence (1/2)

What is human intelligence (IQ/EQ – objective/subjective)?

- Definition from a dictionary and encyclopedia
- History of intelligence – Aristotle
 - Objects – Natural Sciences
 - Scientific Method (IQ)
 - Learning from experience
- Industrious
 - The Industrial Revolutions
 - Universal Design
- Emotional intelligence (EQ)

12

Human and artificial intelligence (1/2)

Some of these bullets are expanded further in subsequent slides, but equally we could expand on these points on this slide.

Slide 13 – Human and artificial intelligence (2/2)

Human and artificial intelligence (2/2)

What is artificial intelligence?

- Definition
- History of artificial intelligence
 - Turing Machine, 1950s, AI Winters
 - Machine Learning from experience
- Digital Human – Cognitive simulation – Modelling the brain
- Deep Learning and Neural Networks

13

Human and artificial intelligence (2/2)

Some of these bullets are expanded further in subsequent slides, but equally we could expand on these points on this slide.

Slide 14 – Dictionary definition of intelligence – IQ & EQ

Dictionary definition of intelligence – IQ and EQ

- *The Concise Oxford Dictionary*: 'quickness of understanding; wisdom. The collection of information.'
- *Cambridge International Dictionary of English*: 'the ability to understand and learn and make judgements or have opinions that are based on reason.'
- Wikipedia: 'problem solving, reasoning, self awareness, creativity, emotional knowledge.'
- Good essay and Video: <https://www.britannica.com/science/human-intelligence-psychology>
- Learn from experience, adapt, understand and handle abstract concepts, manipulate our environment.

14

This is an opportunity to explore what exactly human intelligence is. Here are three definitions from different sources.

Note they are similar but not the same – so do we really understand human intelligence? Get the delegates to give you some of their definitions.

Try not to get side-tracked into a philosophical debate.

If a white board or flip chart is available why not jot them down? You could use them as a reference later.

Slide 15 – Aristotle

Aristotle

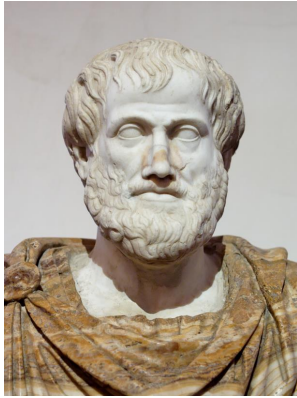


Image from:

<https://en.wikipedia.org/wiki/Aristotle>

364BC to 322BC – the father of western philosophy

He was the first to write about OBJECTS and laid the foundations of:

- Ontology – the natural of being, knowledge, engineering
- The Scientific Method

Today, we teach:

- Natural Science
- Data Science
- Computer Science
- Social Science
- Artificial Intelligence – a universal subject ???

15

Aristotle started the idea of systematic learning via the nature of objects.

This approach led to the scientific method that gives human and artificial intelligence rigour.

Do some reading on Wikipedia about Aristotle's contribution to natural sciences.

He laid the foundation for knowledge engineering, computer science and physics.

Slide 16 – The scientific method – objective

The scientific method – objective

- Empirical way we acquire knowledge:
 - Careful observation
 - Rigorous skepticism
 - Formulate a hypothesis
 - Test with experiments
 - Refine the hypothesis.
- Iterative and cyclical, we build on our results and we *learn from experience*.
- We publish our results so others can check (peer review, transparency, reproducible).
- The Scientific Method and learning from experience led to Machine Learning (ML) – it helps us daily.
- Further reading: https://en.wikipedia.org/wiki/Scientific_method

16

In the Foundation course we introduce the idea of a technological robust AI.

In the 1980s' AI adopted the scientific method. Professionals need the scientific method to produce robust and trustworthy AI. Indeed, the industrial revolutions are a consequence of the scientific method being used to enhance society.

Slide 17 – Emotional intelligence (EQ) – subjective

Emotional intelligence (EQ) – subjective

- The ability to understand one's own and others' emotions
- The ability to use this understanding to adapt to and change an environment
- The ability to empathise and make a judgement
- The hardest problem in AI is consciousness!
- Current scientific research is adding to our understanding.

BUT, social science is using the scientific method in:

- Economics, politics, geography, health, sociology, psychology, marketing ...
- Further reading: https://en.wikipedia.org/wiki/Emotional_intelligence

17

It's not just IQ that we need to understand; part of our intelligence is the ability to understand ourselves and others.

If we are to manipulate our environment, we must have emotional intelligence also.

We are conscious yet we don't have a clear theory of consciousness or indeed why we have consciousness.

How could an autonomous robot have empathy without emotional intelligence?

Slide 18 – The industrial revolutions

The industrial revolutions

- First, 18th & 19th centuries: Europe and USA – steam engine, rural societies became urban and industrial.
- Second, 1870–1914: electricity allowed mass production and technological advances such as the internal combustion engine, telephone and light bulb.
- Third, 1980s: digital, ICT (Information and Communications Technology), personal computer, internet and automation.
- Fourth – the present: exploits the digital revolution and is disruptive, driven by AI, robotics, IoT (Internet of Things), plastic printing, nano-technology, bio-engineering autonomy... Named by Klaus Schwab – founder of the World Economic Forum.

THE FOURTH INDUSTRIAL REVOLUTION IS CHANGING EVERY AREA OF OUR LIVES – See the Reading list.

18

Human intelligence has led us to the industrial revolutions.

We are in the fourth industrial revolution but what does this mean if we think about AI? It means we will have more robots doing routine monotonous task – doing the heavy lifting.

Introduce the idea of humans and machines working together at what each are good at.

Slide 19 – Universal design – design for all

Universal design – design for all

- We can now design for all people of whatever ability and age
human plus machine (robot, computer, system...)
- It's about being more human, improving us as humans:
 - In performance
 - Socially

We are going to re-imagine every area of our lives – Daugherty and Wilson

Further Reading:

- https://en.wikipedia.org/wiki/Universal_design

Motivational example (Makes People Cry):

- <https://developer.apple.com/videos/play/wwdc2017/110/>

19

If humans can augment human intelligence, we must design for all.

In the Foundation course we go deeper into the concept of human-centric AI.

As a consequence of Universal Design we should become more Human – true to our own DNA.

Slide 20 – Artificial intelligence

Artificial intelligence

Intelligence demonstrated by machines

Computer science view:

- *Intelligent agents* perceiving their environment and taking actions to achieve a goal.*
- Some traditional goals are sometimes called narrow or weak AI:
 - Reasoning, planning, learning, natural language processing, image recognition...
- Artificial General AI, sometimes called strong AI:
 - Perform a full range of tasks
 - Some predict it will be 2050 before we can achieve this.
 - WE ARE NOT SURE IF WE WILL EVER UNDERSTAND CONSCIOUSNESS

* https://en.wikipedia.org/wiki/Artificial_intelligence

20

Explain the computer science view of AI. It somehow misses the point of what emotions are. It explains that we are already good at narrow AI. Engineers and scientists use this every day.

Strong, or Artificial General, AI is some way off. It will be able to perform a full range of tasks, but it is a long way off.

Academics believe we will achieve this but we just don't know when and it will certainly not be any time soon.

Slide 21 – The history of AI and Machine Learning

The history of AI and Machine Learning

- 18th Century Mathematical development of statistics (Bayes Theorem) and the first computer description and algorithm – Ada Lovelace
- 1950s Turing Test – ‘Computing Machinery and Intelligence’. Machines play draughts. Dartmouth College – first use of the term Artificial Intelligence – John McCarthy
 - Electronic Neural Net
- 1973 Resources withdrawn from AI research – Sir James Lighthill's Report
 - <https://www.youtube.com/watch?v=03p2CADwGF8>
- 1980s David Rumelhart and James McClelland Parallel Distributed Processing and Neural Network Models
- 1997 Deep Blue (11.4 GFLOPS) beats world chess champion – won by searching 200,000,000 moves per second – iPhone 7 (400 GFLOPS)
- 2016 Google Deep Mind Alpha Go beats Lee Sedol at Go



https://en.wikipedia.org/wiki/Ada_Lovelace#First_computer_program

21

Research the history on Google or Wikipedia. Add your own examples. Point out that the first computer program was written by Ada Lovelace.

The Turing Test is famous. Explain what it is and why it's so important.

Alpha Go is a big step toward algorithms that learn by themselves. Explain why Alpha Go was such a success. Highlight that it identified a move that won the game and taught the masters!

Do not attempt to watch the video as it's 1hr 23 mins long.

Slide 22 – Machines learn from data

Machines learn from data

- Machines learning from experience by analysing data.
- Machine Learning is a scientific way of analysing data – data scientist, data mining.
- Machine Learning helps engineers, scientists, marketing, doctors...
- Machine Learning gives us superhuman capability – the searching of the WWW in seconds, surgical robots, identifying patterns in lots of data...
- Machine Learning can give disabled / older people more independence – voice control, home automation, autonomous vacuum cleaners and lawn mowers, drone delivery...

WE ARE RE-IMAGINING ALL ASPECTS OF OUR LIVES

- Machine Learning is focused on computers learning from data – AI is about systems (machines) that display human intelligence.

22

Machine learning is popular at the moment and the market for it is growing steadily.

ML is a subset of AI. Later in the course we will show the difference so attendees can explain the difference between human, artificial and machine learning.

ML augments our intelligence by learning from data; this is different to what humans do which is learn from experience.

Slide 23 – Formal Tom Mitchell definition of ML

Formal Tom Mitchell definition of ML

Samuel Arthur (IBM – 1959) first used the term 'Machine Learning'.

Tom Mitchell's definition is more widely quoted:

'The field of Machine Learning is concerned with the question of how to construct computer programs that automatically improve with experience.'

'A computer program is said to learn from experience, E , with respect to some class of tasks, T , and performance measure, P , if its performance at tasks, T , as measured by P , improves with experience, E .'

23

Formal Tom Mitchell Definition of ML.

Research the Tom Mitchell definition of ML.

Highlight that this is very much a computational description and that AI is a broader subject.

Slide 24 – Heuristic – sometimes works

Heuristic – sometimes works

‘Heuristic – a strategy derived from previous experiences with similar problems.’

In Machine Learning, ‘Heuristic’ means a technique for solving a problem more quickly where classical techniques are too slow – a bit like a shortcut, rule of thumb, trade offs, developed using trial and error, discovery and experimentation...

...experts teach a ML algorithm how they do it, transform a problem into a simpler form which is easy to work with (e.g. reduction)

24

One of the big problems with machine learning is the combinatorial explosion. A heuristic approach can help us overcome this; an expert gives us a good best guess.

The shortcut or ‘rule of thumb’ allows machines to obtain an answer much quicker!

Find your own examples!

Slide 25 – A human being is more than IQ and EQ

A human being is more than IQ and EQ

ML can give us superhuman skills and improve the quality of our life, BUT

- We are feeling, emotional and conscious beings...
- Our brain has a conscious and sub-conscious capability
 - It interacts with chemical and electrical signals from our physiology, our environment, our memory, other people
 - It has developed over evolutionary timescales – evolution has chosen sight, smell, hearing, taste and feeling as our data collectors
 - As well as the less well know; e.g. balance and acceleration (vestibular), pain, internal (hunger)
- Intuition often helps us make decisions, motivate us – ‘what’s your GUT feeling?’ – our stomachs and hearts have brains – literally!

25

Machines can enhance or magnify our skills and capabilities but a human is more than a computer program.

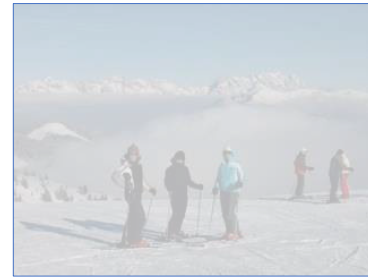
Introduce the idea of consciousness and the conscious and sub-conscious aspects of being human.

When we dream, are we conscious? Explore this with the attendees.

Slide 26 – Go with your gut feeling – Magnus Walker

Go with your gut feeling – Magnus Walker

<https://www.youtube.com/watch?v=KDQrMoksJ4Q>



- TACIT Knowledge: Knowledge that we pass on without being able to write it down, without being explicit – example: we remember a face not its features, hard to put into words!

26

An interesting video to watch (not in the course) about someone who used his gut feeling to build an amazing life.

Also, in this slide is an example of just how quickly humans can identify objects from few examples. Given the right hand side image, a human (child) would find it easy to identify the skiers going from right to left.

The hard bit for AI is that even though a human finds this easy, we can't teach people how we do it. This is tacit knowledge.

Slide 27 – The digital human

The digital human

Computer simulations are used to understand the whole human body.

- Ergonomics (reduce fatigue, improve well-being, improve performance, reduce errors...)
- Drug testing – modelling the physiological response to drugs
- Brain function – electrochemical, response to drugs, hormones, dehydration
- Sense function – how we see?
- Imagine if we could assess the evolutionary effect of food, exercise and medication on the human body.

27

Imagine if we could simulate the whole of the human body, including the brain? It would lead to huge improvements in our well-being.

Drugs tested, medicine improved, loss of senses cured? The long-term effects of drugs, food and stress tested!

Slide 28 – Human brain inspired AI – ‘Deep Learning’ (DL)

Human brain inspired AI – ‘Deep Learning’ (DL)

Deep Neural Networks (DNN) are used in:

- Speech recognition
- Image recognition
- Medical diagnosis
- Natural Language Processing (NLP) – Echo, Siri, Alexa, Cortana...

Inspired by the physiological construction of the human brain, DNN are widely thought to have revolutionised AI – WHY?

It closely matches the AI intelligent agent concept.

28

Very recent advances in Deep Learning have accelerated the acceptance and use of AI, in particular Machine Learning.

Here we see machine learning approaching the simple idea of the agency of a human. This is the Deep Neural Network and it is inspired by the human brain. It learns by itself to achieve a goal.

Slide 29 – What have we learned?

What have we learned?

Artificial intelligence is a diverse, fascinating, complex and rich subject and it is growing and learning.

The Fourth Industrial Revolution has the potential to change every aspect of our lives – make us more human.

'Learning from experience' can be enhanced by Machine Learning – a toolkit to re-imagine every area of our lives.

Machine Learning and AI are driven by the scientific method and need good quality data.

29

In summary we have learned that . . .

- Artificial intelligence is a diverse, fascinating, complex and rich subject and it is growing and learning.
- The Fourth Industrial Revolution has the potential to change every aspect of our lives – make us more human.
- 'Learning from experience' can be enhanced by Machine Learning – which is a potential toolkit to re-imagine every area and aspect of our lives.
- Machine Learning and AI are driven by the scientific method and need good quality data.

Slide 30 – Example exam question

Example exam question

What is an example of human intelligence?

- (a) Running a marathon.
- (b) Watching a movie.
- (c) Tasting food.
- (d) Identifying a horse in a misty field.

Answer: ?

30

The answer is (d). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 31 – Example exam question

Example exam question

What is NOT used to define Heuristic?

- (a) Child's play.
- (b) Discovery.
- (c) Trial and error.
- (d) Experimentation.

Answer: ?

31

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 32 – Example exam question

Example exam question

Whose definition of Machine Learning is often quoted?

- (a) Marvin Minsky.
- (b) Tom Mitchell.
- (c) Douglas Adams.
- (d) Sir James Lighthill.

Answer: ?

32

The answer is (b). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Exercise One


Opportunities for an AI system

Slide 33 – Explore some of the key questions when building an AI system business plan

Exercise One

Opportunities for an AI system

Explore some of the key questions when building an AI system business plan

33

See Exercise book. Exercise One – Opportunities for an AI system

This exercise is self-explanatory – given the definitions, the exercise reinforces the content of the first section and gets the attendees to explore key questions when starting to define an AI project. Be disciplined with timing – guide the session so that only 5 minutes is spent on each question. If time permits and there aren't too many attendees go around the room so each person can explain briefly what they found! Do this for each question!

Objective: Allow participants to write down their first AI project(s) and in doing so explore key elements of an AI project. What would the AI system do? Where's the 'learning from experience'? What are the benefits, challenges and risks? Who will do the project? How important is the work and how much will it cost?

Tutor facilitated:

1. Spend a minute on each question allowing the participants to develop an idea or ideas.
2. When everyone has attempted each question, go through them allowing each participant to give a quick overview of their answers.
 - Allow brief discussion but avoid over indulging in excessive debate.
 - Key is to build confidence in starting to define an AI project.
 - Remind people that AI is about building intelligent entities – where's the 'learning from experience' – AI could well be a small part of a larger project.
 - Question 5 is the most interesting – emphasise STARTING with easy projects first and avoid the Bermuda Triangle!

Session 3

Examples of AI – *benefits, challenges and risks*

Slide 34 – Title slide



This section broadens the scope of AI via looking at examples of where it is applied.

In doing so, it highlights the Challenges and Risks an AI project poses.

In particular it looks at a typical Machine Learning project and what's involved from a computing point of view.

Slide 35 – Benefits, challenges and risks

Benefits, challenges and risks

- What do we need? – Functionality, software and hardware
- Examples of ML – OCR, R&D, Engineering, Health and Social, Entertainment, Sales and Marketing
- ML Enablers
- Funding – UKRI – Innovate
- Risks – resources, complexity, data, culture, misuse
- Challenges – team, project style, data, ethics
- Opportunities – robotics, NLP scripting, Big Data, IoT, ANN, Open Source, WWW

35

This slide gives an overview of the session.

Highlight the funding the UK is putting into AI. Remember to reinforce that ML is part of the AI mix. Robotics is a good example of building an AI entity rather than learning from data.

Slide 36 – ML – What do we need?

ML – what do we need?

- **What FUNCTIONALITY do we need to learn?**
 - Collect data
 - Prepare data
 - Algorithms to learn from the data
 - Present data
 - Deploy the ML (product, service, publish)
- **What SOFTWARE do we need for the above?**
 - Write our own (e.g. programming languages: R, Python, SciKit-Learn, TensorFlow, C++, Obj C, Fortran, object orientated ...)
 - Open Source (e.g. Amazon, Google, IBM, Apple, Microsoft)
 - Commercial (e.g. Matlab, Micosoft Azure, IBM Analytics, Google Analytics)
- **What Hardware do we need for the Software?**
 - Tablet or smart phone
 - Desktop computer
 - A Computer Cluster
 - High Performance Computer – Cloud Service

36

This slide identifies some key steps in a Machine Learning project.

Ask the delegates to suggest what they would do or how it applies to their profession.

Slide 37 – 1970s – Optical character recognition (OCR)

1970s – Optical character recognition (OCR)

- Widely thought to be the first AI product, 1974.
- Kurzweil Computer Products, Inc.
- Text-to-speech synthesiser so a blind person can read text.
- Today, we don't associate OCR with AI or ML because it's routine and we take it for granted.
 - It's just an algorithm implementing some ML analysis.
- Often the first 'hello world' ML project is OCR, but we analyse handwritten text which is more involved than typed text.
- Moved on to speech-to-text or dictation – we rarely see typing pools nowadays...
 - More advanced version work with hand written as well typed text images.
- Exciting area is Natural Language Processing (NLP) or Natural Language Programming e.g. Apple Script.

37

Optical Character Recognition was developed by Ray Kurzweil. This is often the first 'hello world' ML programme.

Highlight that this is now taken for granted and not recognised as Machine Learning. Today the challenge is handwritten as well as typed text.

OCR: the fashion of today is the need of tomorrow!

Slide 38 – Research and development – R&D

Research and development – R&D

- R&D is the professional embodiment of learning from experience and the scientific method.
- AI and ML are part of the R&D toolkit for the innovation engine room.
- AI is a fundamental part of R&D.
 - Enhances human capabilities – data mining, analytics.
 - Reduces R&D timescales.
 - Experimental selection (before building physical experiment).
 - Weather analysis – ensemble simulations analyse using ML most likely forecast.
 - Simplify analysis by coupling sensors to simulations.
 - Product development – exploring a wider range of design options.
 - Use AI in literature searches to identify key concepts and papers.
 - Use AI to collect data – saving researchers time to focus on the hypothesis and results.

38

This slide is full of examples of ML – ask the delegates if they have any experience with any of them and if so, could they describe it? R&D is first because it will fundamentally use the scientific method.

Slide 39 – Engineering

Engineering

- Robotics
 - Extreme environments (where humans can't be, e.g. sterile, vacuum, underwater, chemical hazards, radiological hazards, physical hazards)
 - Health and social care
 - Manufacturing (3D printing, smart supply chain and factories)
 - Autonomous vehicles (cars, aircraft, trams, trains, drones)
 - Swarms (multiple robotics working towards common goals)
 - IoT
- Design
 - Optimisation
 - Aesthetics
 - Virtual and augmented reality
 - Simulation
- Control and Automation
- AI hardware – optimised hardware for ML mathematical operations (convolution, GPUs, OPUs, CPUs)
- Product nervous system – learning from the product (RR engines) in operation

39

Engineering will be changed fundamentally by AI – products now will be expected to be intelligent entities (maybe connected to the IoT).

Every stage of an engineering project, product or service will be enhanced by AI.

Mention to the delegates that most engineering graduates will be familiar with ML and AI mathematics and computing, as will scientific and mathematical graduates.

Slide 40 – Health and social care

Health and social care

- Health care
 - Diagnosis and treatment selection
 - Drug development
 - Smart hospitals and patient interaction
 - Patient monitoring (temperature, BP) 24/7 release nurse time
 - Robotic surgery (extending a surgeon's capability – nano-scale)
 - Image analysis
 - Genetic analysis (DNA)
- Social care
 - Monitoring and support at home (dementia help, drug administration)
 - Robotics (movement, bathing, food preparation, housework, toilet...)
 - Social interaction
 - Home automation; WATCH Todd Stabelfeldt – 'Convenience for you is independence for me':
<https://developer.apple.com/videos/play/wwdc2017/110/>

40

Health care stands to benefit enormously from AI and ML, medicine in particular is based on statistical methods and the scientific method.

Explore how our health and social care will be changed (possibly distrusted by) AI, examples are robotics, diagnosis, medical chatbots.

Don't watch the video it's too long. The video shows an example of someone who has been a fundamental user of technology.

Slide 41 – Entertainment

Entertainment

- Computer games
 - Multi-player human and machine games
- Interactive media and news
- Immersive audience – Virtual Reality and Augmented Reality
- Personalised content selection (already here)
- CGI – AI-enhanced movies (colouring of B&W images)
- Personalised movie content – advertising in movies based on your preferences

41

Entertainment already makes use of ML in particular.

Ask the delegates how it's used today (suggestion of content – Netflix Apple Music).

Content generation is also being enhanced with automated subtitling and captioning.

Animated movies and B&W movies made into colour are other good examples.

Game technology may become a major way of teaching ML systems where there is a lack of data – i.e. we simulate it.

Slide 42 – Sales and marketing

Sales and marketing

- Chatbots (FAQ, advice line sales assistants, helplines)*
- Analytics (identifying customers, opportunities, demand, supply)
- Preventing fraud
- Streamlining marketing, marketing suggestion...
- Product pricing
- Market-size prediction
- Website design
- Social media analytics
- Search engine optimization

*Alan Turing proposed a test where an observer is asked to determine if they are talking with a computer or a human based only on text-based questions:

https://en.wikipedia.org/wiki/Turing_test

CHATBOTS allow humans to deal with ambiguous problems that require judgement!

42

It's important to mention that Alan Turing's test started the concept of a chatbot! In sales and marketing, we must emphasise the potential for unethical use of ML and AI.

Ask the delegates where this might happen.

Slide 43 – Logistics – planning and organisation

Logistics – planning and organisation

- Data analytics are a VERY commercially successful business tool
- Re-humanising the workplace – removing monotonous task, improving accuracy, removing low value tasks
- Smart factories
- Smart integrated supply chain
- Smart integrated delivery
- Autonomous robotics
- Intelligent agent modelling – learning from simulated experience
- Knowledge engineering – learning from the experience of experts
- Human resources – search, selection and recruitment
- Agile projects – ML-driven projects
- Enhanced security
- Predictive maintenance
- Automated planning
- Internet of Things

43

Some of the earliest and most successful applications of ML are logistics and organisation. This work started just after the Second World War and was called Operational Research. This is taught to business, engineering and mathematics graduates.

Ask the delegates if they think Agile Projects are a good idea for ML and AI projects.

Slide 44 – ML enabler – internet of things – BIG DATA

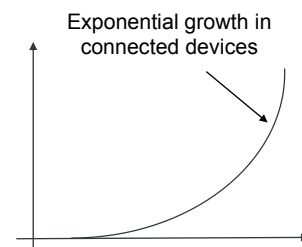
ML enabler – internet of things – BIG DATA

The Internet of Things (IoT) is the network of physical devices, vehicles, home appliances, and other items embedded with electronics, software, sensors, actuators, and connectivity which enables these things to connect and exchange data.

The estimated number of devices connected including mobile phones and tablets is 15-20 billion. Estimates vary – we will generate lots of data.

BIG DATA is often described as having high velocity, high volume and a wide variety.

https://en.wikipedia.org/wiki/Internet_of_things



44

The Internet of Things has a huge potential to help everyone. It is an example of a key enabler of ML.

Make sure to highlight the definition of Big Data.

Slide 45 – ML enabler – cloud high performance computing

ML enabler – cloud high performance computing

- Large data centres with parallel super computers
 - On-demand charge per hour
 - Handle Big Data
 - Develop product on the cloud served from HPC (AWS, IBM, Google, Microsoft)
 - 1 to 1000s processors
- Open Source software
- Specialized hardware, GPUs, CPUs, high bandwidth networks and internet

EU currently has plans for an Exa-scale HPC facility to model weather – 10 years to plan

IBM's Deep Blue (11.4 GFLOPS) has less processing power than the current iPhone 7

[https://en.wikipedia.org/wiki/Deep_Blue_\(chess_computer\)](https://en.wikipedia.org/wiki/Deep_Blue_(chess_computer))

https://en.wikipedia.org/wiki/Apple-designed_processors

45

Cloud High Performance Computing is cheap and easily available. AI and ML often need significant computing power. Often Cloud HPC has the best hardware and open source software for a very competitive price.

Slide 46 – ML classification examples – boosting & clustering

ML classification examples – boosting and clustering

Boosting is a Machine Learning approach that turns weak learners (slightly better than random guessing) into a strong learner (well correlated with the true classification).

'Take lots of educated guesses and make a good learner!' – Or a group of experts make better decisions than a single expert!

Clustering is a Machine Learning technique that groups objects into clusters based on similarities. Exploratory data mining is a good example, a quick look at the data.

Random Decision Forests – Uses an ensemble (multitude, orchestra) of decision trees to improve their performance.

46

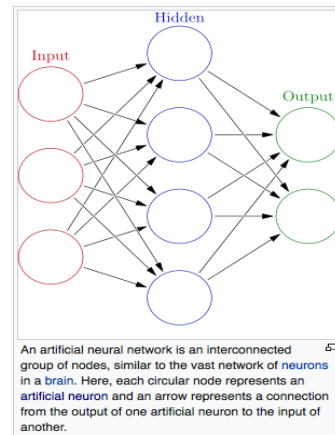
This slide moves away from enablers to some examples of ML that delegates will come across in the reading list and as tutorials online.

Take one of the types and explore in a little more detail.

Slide 47 – ML enabler – Deep Learning artificial neural networks

ML enabler – Deep Learning artificial neural networks

- Based on a mathematical representation of the human brain
- Deep Learning is a step change in ML capability
- Neural Networks have made significant progress in recent years
- **Require training and are black boxes – it is difficult to explain the results**
- Very promising results in Bioinformatics, Speech Recognition, Image Processing, Natural Language Processing
- Typically needs lots of computer resources
- IT LEARNS FROM STRUCTURED AND UN-STRUCTURED DATA



https://en.wikipedia.org/wiki/Artificial_neural_network

47

Deep Learning has driven a large number of new application areas of ML. Give a few examples.

Highlight that they are black boxes and difficult to explain or understand if they do not perform as expected.

Emphasise that neural networks learn from structured and unstructured data.

Give a brief overview of how an NN works. It's not essential to know the intricate nature of them.

Slide 48 – ML enabler – Deep reinforcement learning

ML enabler – Deep reinforcement learning

Google's Deep Mind have developed Machine Learning capable of beating the World Go Champion: www.deepmind.com

Other Examples include:

Swarm Intelligence – driven by the need to understand biological systems like bacteria, lots of autonomous robots...

Optimisation – making a system better by successively improving a metric or metrics

48

Explain what deep reinforcement learning is and how it is enabling ML to achieve better than human performance in many areas. Alpha Go is the usual example.

Mention that the algorithm learned from many simulated games in a real game proposed a move that the masters thought naive until it turned out to be the deciding move that won the game.

Slide 49 – Funding

Funding

UKRI (<https://www.ukri.org>)

Innovate UK (<https://www.gov.uk/government/organisations/innovate-uk>)

- Provides grants and support to develop technology from basic TRL 1/2 understanding to TRL 9 Commercial exploitation
- TRL – Technology Readiness Levels developed by NASA and adopted by the EU and UK.
 - http://www.earto.eu/fileadmin/content/03_Publications/The_TRL_Scale_as_a_R_I_Policy_Tool_-_EARTO_Recommendations_-_Final.pdf
- University R&D with Industrial Strategy – value from what we are world class at
- Fantastic examples of state of the art R&D and commercial adoption

49

There are many sources of funding. The UK has set up UKRI and Innovate UK. Highlight the TRL levels and how investment in the levels 2-8 is very rewarding for the government.

Find other sources of funding and explain those also. This is especially important if delegates are UK-based.

Slide 50 – Ethics – the elephant in the room

Ethics – the elephant in the room

- Complex subject – How? Who's responsible? Law? Human rights? Robotic rights?
- If we develop AGI (Artificial General Intelligence) then robotics becomes a major ethical area to understand:
 - UK EPSRC have outlined guides: <https://epsrc.ukri.org/research/ourportfolio/themes/engineering/activities/principlesofrobotics/>
 - International organisations are developing these concepts: <https://futureoflife.org/team/> & <https://ieccetech.org/Technical-Committees/2018-03/First-International-Standards-committee-for-entire-AI-ecosystem>
- Transparency in AI – open source (how far do we take this?)
- Accountability
- Very careful of inequality, diversity, bias, unemployment
 - Did we use biased data? – basis of a conviction
- Weapons
- Healthcare – genetic selection, social exclusion
- Ability to pay – AI charging more to vulnerable people

50

Up to now we have ignored ethics, but the EU has now made Ethical Purpose and Robust AI a core part of its guidelines for Trustworthy AI.

Ask the delegates to give examples of where ethics is important. Later in the day we will explore universal design and in the Fundamentals course we will look at Ethical purpose and Sustainability.

Find an example of where biased data has caused silly or harmful results.

Slide 51 – What humans do well (subjective)

What humans do well (subjective)

- Provide leadership – set the goals
- Are creative
- Can empathise (humans, groups, animals, nature, ideas, ethics)
- Can judge (law, ambiguity, 50/50)

What machines do well (objective – narrow or weak AI focus on a single task)

- Transactions – monotonous tasks
- Prediction
- Iteration
- Adaption

See *Human + Machine* by Paul Daugherty and James Wilson.

51

This slide is a taster for the last session, Human Plus Machine.

Emphasise the areas where humans are better than machines and where machines are better than humans.

Slide 52 – Humans and machines working together

Humans and machines working together

Paul Daugherty and James Wilson have proposed the missing middle where humans and machines experiment and work together to define a new re-imagined future, based on:

Humans complementing machines by:

- Training them – they need data and experts to train them
- Explaining – someone to explain how the machine learned
- Sustainers – making sure the machines are acting appropriately and not being misused

Human augmentation – we gain superhuman powers through:

- Amplification – tools to enhance our abilities, e.g. design, space exploration
- Interaction – AI agent interacts with humans leaving humans to higher value work
- Embodiment – robots and humans in harmony, aware of each other, enhancing each other's abilities

52

This slide shows where machines and humans will complement each other.

Ask the delegates if they can give other examples. If there's time, try to explore one of the examples.

Slide 53 – Automation

Automation

‘Automatically controlled operation of an apparatus, process, or system by mechanical or electronic devices that take the place of human labour.’

<https://www.merriam-webster.com/dictionary/automation>

- No learning from experience
- No human involvement

In Machine Learning a scripting language is used to automate a series of workflow steps on a computer.

53

This slide defines automation. It's important to emphasise that this definition has no learning from experience and has no human involvement. It's an unintelligent implementation of machines.

Slide 54 – ML challenges and risks

ML challenges and risks

Data

- Obtaining data
- Legal (GDPR, IP, copyright) General Data Protection Regulation
- Preparing it for ML – STRUCTURED OR UNSTRUCTURED, encoding, cleaning, missing data

ML algorithms

- Selecting the right one
- Understanding the results (bias, variance, overfitting, underfitting)
- Understanding the differences from a group of ML algorithms
- Combining results of different ML algorithms

Data visualization

- Large amounts of data to visualise

ML results deployment

- Launching and maintaining the system

54

This slide is not an exhaustive list of challenges and risks from ML – our objective here is to get the delegates thinking critically about what is challenging and a possible risk to an ML project.

Explain over or underfitting and that we will go over it in more detail in one of the later sessions.

Slide 55 – ML challenges and risks (1/2)

ML challenges and risks (1/2)

Mathematical and Scientific

- Engineering
- May not be solvable – combinatorial explosion, non-linear...
- Statistical – probability, random numbers
- Linear Algebra – properties of matrices
- Computer and Data Science – data structures, algorithms, graphs
- Vector Calculus – differentiation, integration
- Operational Research
- Control Theory

Hardware Required

- Parallel Computation
- GPU, CPU and OPU (Optical Processing Units)
- Quantum

55

Here we identify some of the challenges and risks that we encounter. The top ones are the subject matter skills and possible challenges. Pick one and go through it in more detail.

A good example is one where a mathematical problem may not be solvable or that we simply do not have the computing power to solve it. Or we may not have the skills to solve it.

Data visualisation is another, e.g. how do we visualise and debug data spread across 1000s of processors?

Slide 56 – ML challenges and risks (2/2)

ML challenges and risks (2/2)

Data visualization and presentation

- Large amounts of data to visualise

Culture

- Fear of AI – society and organisational
- Organisational – fear of failure and experimentation (Victorian values, patronage, ... leadership)

Skills

- Individual – education and experience
- Team – style of project delivery (Waterfall compared to Agile)

56

Probably the hardest problem of all is a person's or group's reaction to the use of AI. Examples could be the culture is 'old fashioned' and based on blame . . .

Admitting that someone doesn't know and needs learning from experience machines to help them. An individual may feel challenged by a machine learning approach.

A no blame agile approach may make others feel uncomfortable if they have come from a right first time culture.

Slide 57 – Example exam question

Example exam question

What part of the human body is the Artificial Neural Network based on?

- (a) Nervous system.
- (b) Brain.
- (c) Hand.
- (d) Senses.

Answer: ?

57

The answer is (b). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 58 – Example exam question

Example exam question

What is a form of Artificial Intelligence?

- (a) Deep Learning.
- (b) Statistics.
- (c) Linear Algebra.
- (d) Graph Theory.

Answer: ?

58

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 59 – Example exam question

Example exam question

Automation is a system that does not require...

- (a) Software.
- (b) Power supply.
- (c) Human Intervention.
- (d) Hardware.

Answer: ?

59

The answer is (c). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 60 – Example exam question

Example exam question

What disadvantage does AI have when compared to a human?

- (a) Little empathic ability.
- (b) Accurate calculations.
- (c) Deal with monotonous tasks.
- (d) Repeatability.

Answer: ?

60

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 61 – Example exam question

Example exam question

An artificial Neural Network is a form of...

- (a) Machine Learning that learns from structured and un-structured data.
- (b) Automation that learns from sensors and the Internet of Things.
- (c) Scripting that learns from unstructured data randomly.
- (d) Biological computing that learns from human emotions.

Answer: ?

61

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 62 – Example exam question

Example exam question

Alan Turing's test inspired what type of conversational commerce program for ecommerce?

- (a) Chatbot.
- (b) Intelligent credit cards.
- (c) Talking money.
- (d) Talking piggy banks.

Answer: ?

62

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 63 – Example exam question

Example exam question

OCR was first commercialised by Ray Kurzweil in which decade?

- (a) 1970s.
- (b) 1940s.
- (c) 1920s.
- (d) 2000s.

Answer: ?

63

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Session 4

An introduction to Machine Learning – *part one*

Slide 64 – Title slide

Session 4

An introduction to Machine Learning – *part one*



BCS Essentials Certificate in Artificial Intelligence Courseware

64

Slide 65 – Machine Learning - part one

Machine Learning – part one

What is Machine Learning? AI to ML

- AI agent and environment
 - Agents types
 - Agent world
 - Typical AI learning tools for agents
- Machine Learning is part of the AI toolkit
- Machine Learning is multi-disciplinary
- Types of Machine Learning

65

This slide outlines what is covered in this session.

As you are going through, make sure to emphasise that we will show how the general learning from experience learning agent links to Machine Learning. Here we want to show that creating intelligent entities needs more than Machine Learning.

Slide 66 – Formal Tom Mitchell definition of ML

Formal Tom Mitchell definition of ML

Samuel Arthur (IBM, 1959) first used the term 'Machine Learning'.

The Tom Mitchell definition is more widely quoted:

'The field of Machine Learning is concerned with the question of how to construct computer programs that automatically improve with experience'

'A computer program is said to learn from experience, E , with respect to some class of tasks, T , and performance measure, P , if its performance at tasks, T , as measured by P , improves with experience, E .'

LEARNING FROM DATA – ENGINEERS NEED MORE THAN DATA IF WE ARE GOING TO BUILDING INTELLIGENT ENTITIES

66

This is the widely accepted definition of machine learning by Tom Mitchell.

Explain both the general one that is quoted and the formal definition with each of the variables.

Remind them that engineers need more than data if we are going to build products!

Slide 67 – Engineers build models every day

Engineers build models every day

Top university engineering departments build models EVERY DAY

AI can help engineers build better models which means:

better engineering – better products – better society

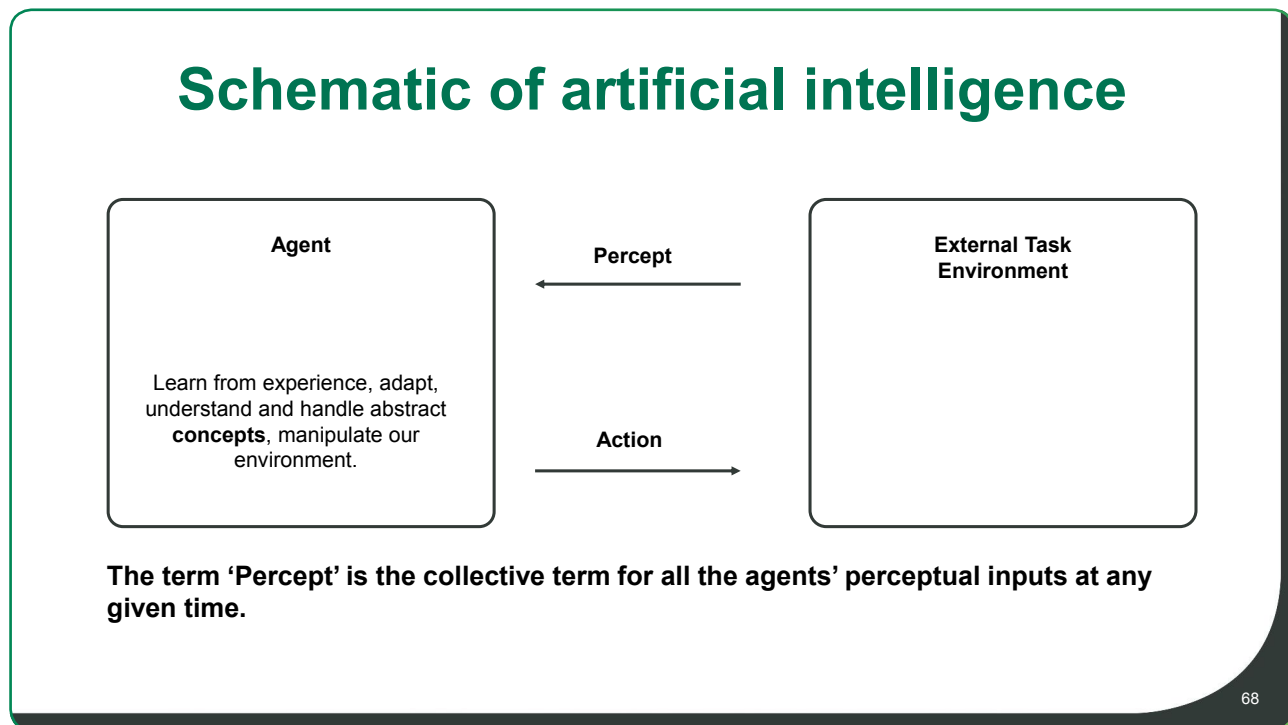
Engineers use partial differential equations, experiments, computational physics and simulations, statistics... Models, models, models

Patrick Winston, MIT – AI is the modelling of representations that support models targeted at thinking, perception and actions.

67

This slides shows how engineers are adopting AI to build intelligent entities. We want to emphasise that engineers (and scientists) use models to build products, experiments and services.

Slide 68 – Schematic of artificial intelligence



Describe the key components of the Schematic of Artificial Intelligence. Also make the link between the Britannica definition of human intelligence and this schematic.

Slide 69 – We assume agents have the following

We assume agents have the following

We expect them to be rational and this depends on four things:

1. The performance measure that defines the criterion of success.
2. The agent's prior knowledge of the environment.
3. The actions that the agent can perform.
4. The agent's percept sequence to date.

Stuart Russell and Peter Norvig's *Artificial Intelligence – A Modern Approach*, 3rd edition defines a rational agent as:

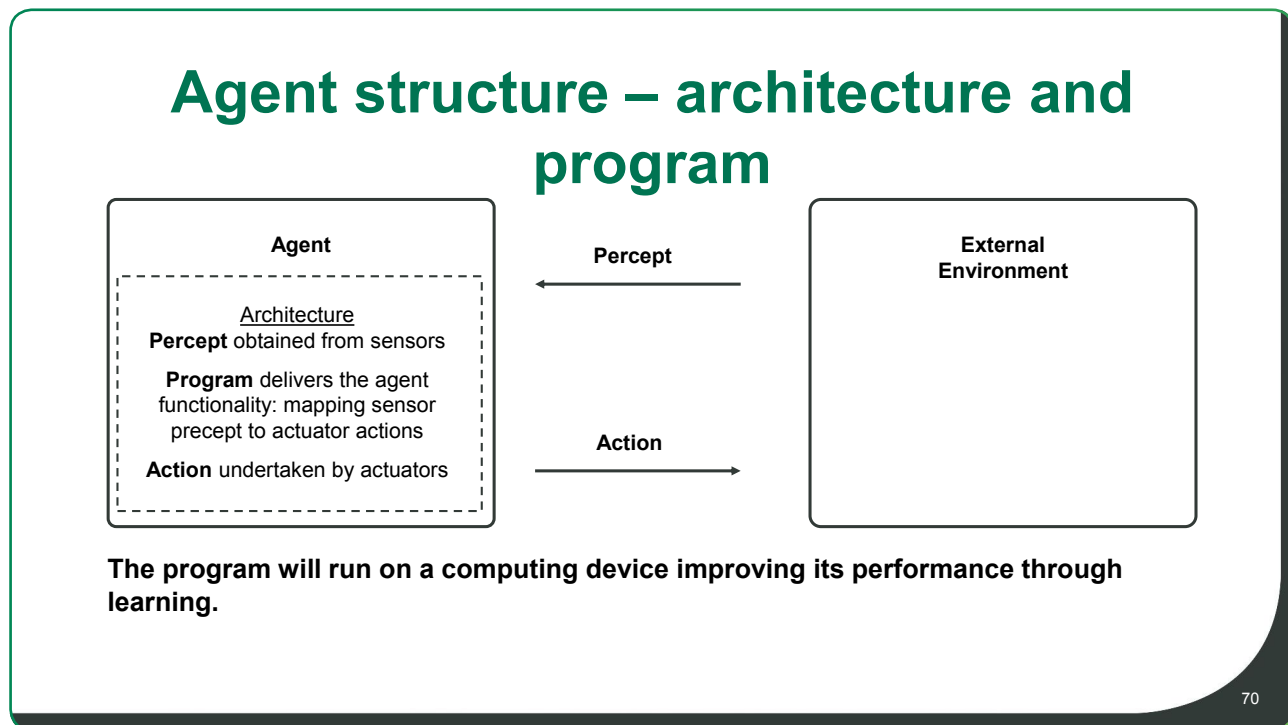
'For each possible percept sequence, a rational agent should select an action that is expected to maximize its performance measure, given the evidence provided by the percept sequence and whatever built-in knowledge the agent has.'

69

This slide describes our learning agent as rational; this is made up of four things.

Go through the Russel and Norvig explanation of a rational agent and ask delegates if they have examples of where they could apply this (simulations of traffic or aircraft perhaps).

Slide 70 – Agent structure – architecture and program



These slides explain the main terms that let the learning agent manipulate its environment and understand its environment and map its percept of the environment to actions on the environment.

Slide 71 – Agent examples

Agent examples

Agent Description	Performance Measure	Environment	Actuators	Sensors
Central heating thermostat	Temperature, heating cost	Building, inhabitants, heating system	Inhabitant display, boiler, power	Temperature, keypad, phone, computer
Interactive sales chatbot	Number of sales	Customers, sale environment (internet, store, phone)	Robot, display, speaker	Keyboard, microphone, camera, kinesthetic sensors

71

Go through each of these examples and ask for examples from the delegates.

Slide 72 – Types of agent – what's missing?

Types of agent – what's missing?

Reflex agent

- The program selects actions based on the current percept
- Simple to understand and program

E.g. central heating overheats, program selects the action to switch off the power

Model-based reflex agent

The agent has a model of the world:

- Can make up for a lack of sensor (virtual world that doesn't need sensor data)
- Program now looks at the percept and updates its own internal world (**state**)
- Program can assess the possible actions and future states and uses reflex agent approach to determine what actions to take

E.g. underwater vehicle loses visual sensors (silt – not enough light), continues using 3D-mapped geometrical model

72

The next two slides go through four types of agent.

Describe each and ask what is missing in each of the agent descriptions.

Slide 73 – Types of agent – what's missing?

Types of agent – what's missing?

Goal-based agent

- The program needs more than just sensors and an internal world to implement the agent's functionality – it needs a goal
- These programs are more versatile and flexible – can adapt to changes

E.g. autonomous vehicle can choose one of five exits from a motorway – the goal: safest, quickest, most scenic, cheapest, shortest

Utility-based reflex agent

Utility is the scientific way economists measure an agent's happiness. It's more versatile than a yes/no, happy or unhappy – it measures how useful it is.

e.g. Chabot doctor assesses the efficacy of a treatment based on patients' needs


73

As previous slide.

Slide 74 – What was missing?

What was missing?

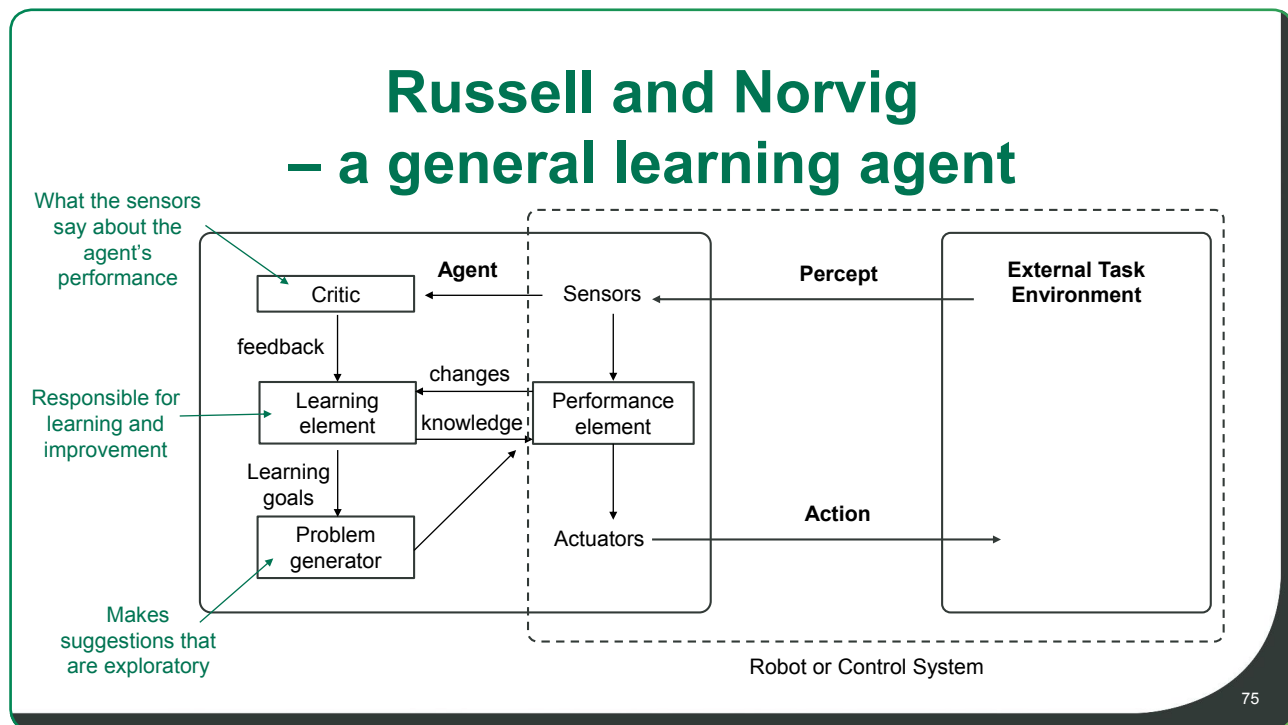
Learning from experience



74

The answer to what was missing – Learning from experience

Slide 75 – Russell and Norvig a general learning agent



Delegates should now be able to see where the learning comes in, describe the learning element and how it relates to the agent models.

The dotted line is sometimes thought of as the control or robot system. We might think of the left hand side of this schematic as where machine learning fits in.

Slide 76 – State of the agent world

State of the agent world

How can we represent the world that supports the making of models?

Increasing Fidelity

Atomic state which is a black box and has no internal structure

Factored state which is vector (list) of attributes made up of Booleans, real-valued or one of a fixed set of states

Structured state which is made up of objects (could have its own attributes) as well as relationships with other objects

We humans describe most things using objects and relationships via natural language – engineers and scientists use these descriptions to build products, services and research.

76

When an engineer builds a model of a product or service, they use models that have a state – the state of the agent world is important.

Explain each of the types of state descriptions.

Remind the delegates of the Britannica explanation of human intelligence – the ability to manipulate the environment.

Slide 77 – Typical agent functionality

Typical agent functionality

Given an inner agent representation of the world what types of functionality would an agent need?

Planning

Searching (multi-agent games, games of chance (rolling dice), route finding, robot navigation...)

Natural language processing

Representing knowledge

Making decisions

Learning from examples

Perception

...

77

Now we have an agent schematic that understands the state of the environment, can manipulate it via actuators and learn (perhaps through machine learning).

This slide gives some of the functionality an agent might need.

Mention that this functionality is used successfully already by engineers, mathematicians and scientists every day. Ask delegates if they have any good examples.

Slide 78 – Machine learning – part of the AI toolkit

Machine Learning – part of the AI toolkit

Machine Learning is the theory and practice of how computers learn from data without being programmed explicitly – REMEMBER Tom Mitchell's definition!

It's useful on its own in understanding data – Big Data, Internet of Things, Spam Filtering, Image analysis, research, engineering, medicine...

Defined by the type of learning it undertakes on data – learning from example.

There are free, open source and transparent systems (functionality, software and hardware) we can start using today!

It is popular for analyzing large data sets (e.g. business analytics).

Contrast this with AI examples – home automation, ROBOTS, home assistants, chatbots, smart phones and smart watches.

78

This is a recap of what machine learning is – highlight the difference between AI and machine learning.

Remind delegates that here we are talking about rational agents.

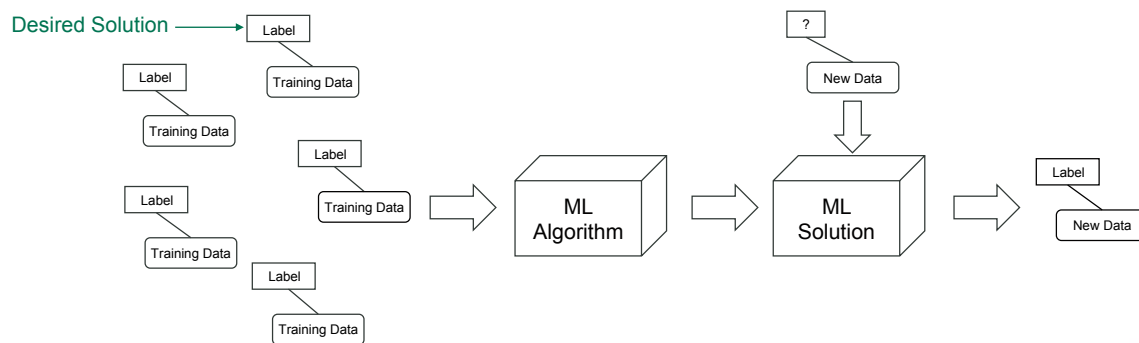
What about emotions and consciousness? This is a simplistic view of AI and a good starting point.

Slide 79 – The types of machine learning

The types of Machine Learning

Supervised Learning – ML learns from the training data that includes the desired solutions.

- The Desired Solution is called a label.
- The ML has a stage where (lots of) training data is used to train the algorithm.
- Once trained the ML system can then tell us something about new data.
- The algorithm maps the input to the output (e.g. classification, curve fitting).



79

Describe what supervised learning is and give examples.

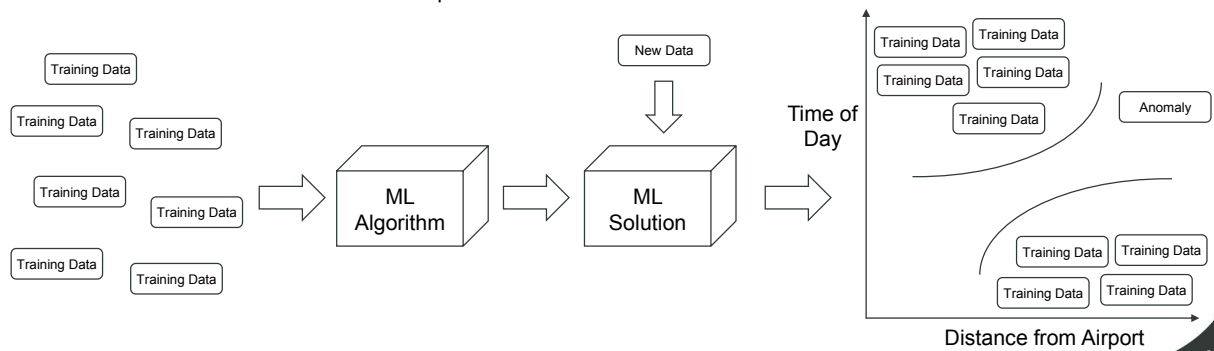
Ask the delegates to think about what steps are involved in building a supervised learning machine learning project. How much data would they need?

Slide 80 – The types of Machine Learning

The types of Machine Learning

Un-supervised Learning – ML learns from the training data that does not include the desired solutions.

- It finds trends, patterns, groups.
- The ML has a stage where (lots of) training data is used to train the algorithm.
- Once trained the ML system can then tell us something about new data.
- Example: fraud detection.



Describe what un-supervised learning is and give examples.

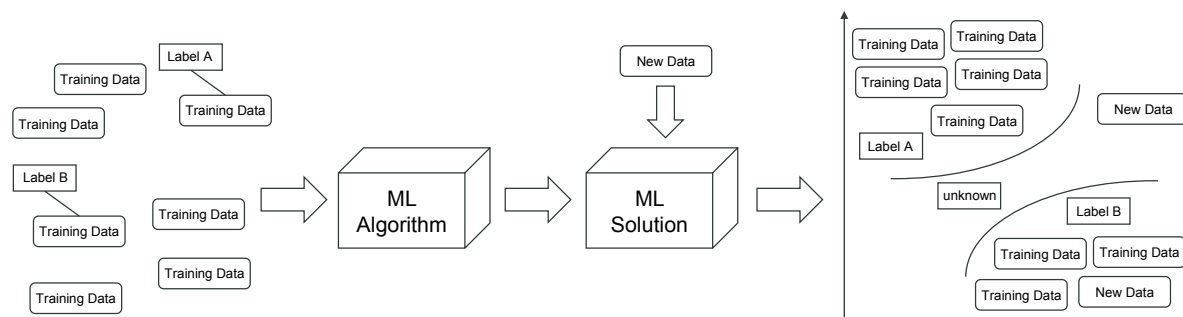
Ask the delegates to think about what steps are involved in building a supervised learning machine learning project. How much data would they need?

Slide 81 – The types of Machine Learning

The types of Machine Learning

Semi-supervised Learning – ML learns from the training data that does includes some labelled data.

- It finds trends, patterns, groups and tries to label them.
- Once trained the ML system can then tell us something about new data.
- Example: photo labelling



81

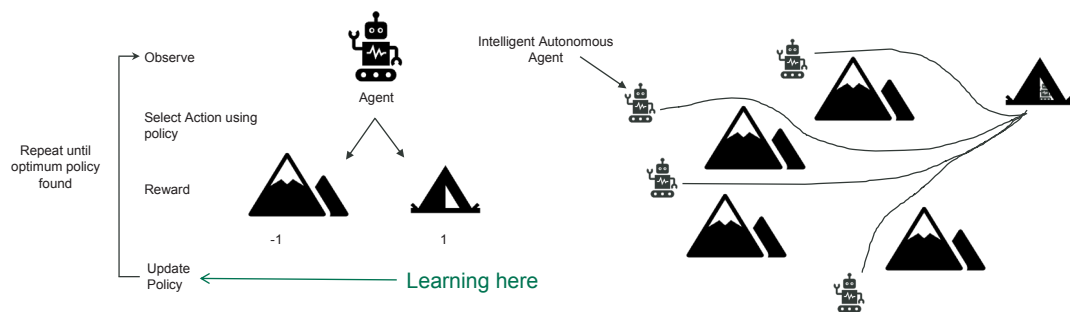
Describe semi-supervised learning. A good example is photo labelling on smart phones.

Slide 82 – The types of Machine Learning

The types of Machine Learning

Reinforcement Learning – an agent can observe an environment, select and perform actions which in return are rewarded or penalised.

- The learning finds its own strategy, called a policy, to get the most reward over time.
- Once trained the ML system can then use that policy to achieve goals.
- Example: robot control, factory automation, scheduling, planning



82

Describe what reinforcement learning is and how it relates to the AI agent schematic. The machine learning is now learning to achieve a goal using a reward or penalties for the actions it takes. It gives robots autonomy to learn.

This is the last slide of ML part one. Maybe have a 2- to 3-minute refresh.

Session 5

An introduction to Machine Learning – *part two*

Slide 83 – Title slide

Session 5

An introduction to Machine Learning – *part two*



BCS Essentials Certificate in Artificial Intelligence Courseware

83

Slide 84 – Machine Learning - part two

Machine Learning – part two

What is Machine Learning (ML)?

- AI agent and environment
 - Agents types
 - Agent world
 - Typical AI learning tools for agents
- Machine Learning part of the AI toolkit
- Types of Machine Learning
- Machine Learning is multi-disciplinary
- Good data and algorithms
- Domain expertise – what is fit for purpose and the scientific method

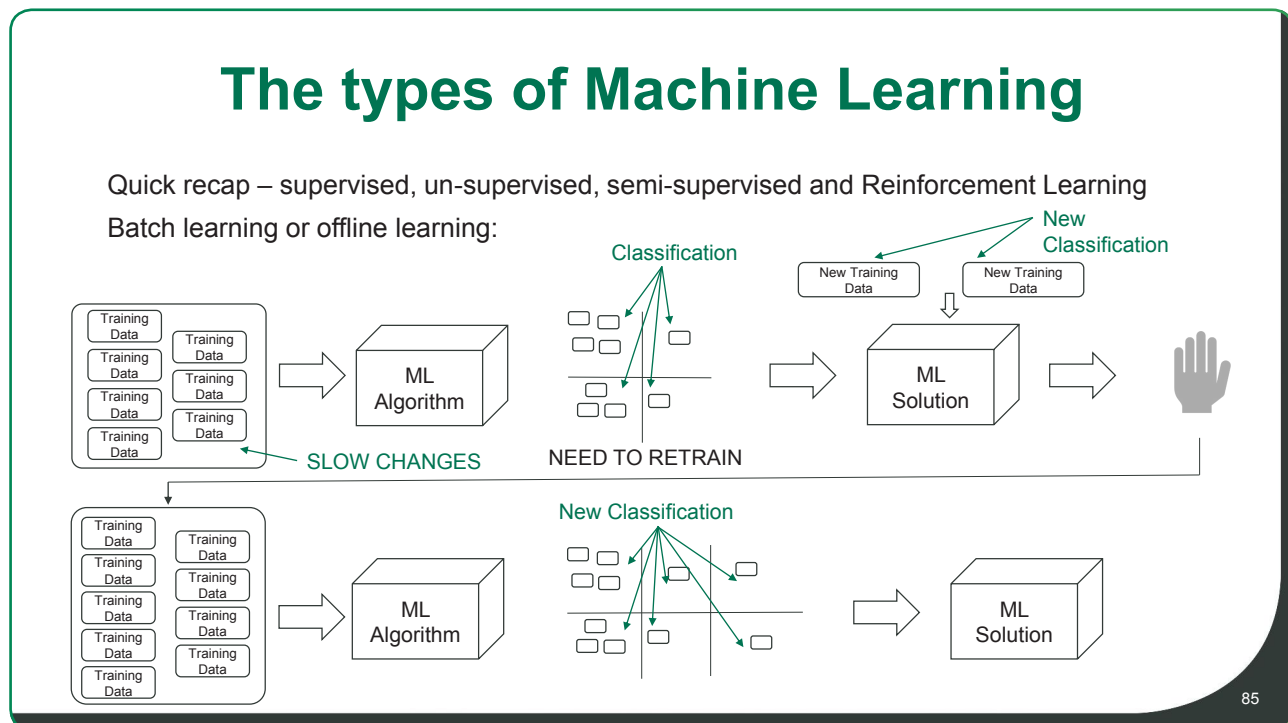
84

Recap what we learned in part one.

Explain that we are going to go into more detail about what we encounter with ML.

Remind the delegates that a domain expert will need to ascertain what is fit for purpose and remind them that AI is based on the scientific method.

Slide 85 – The types of Machine Learning



Recap the types of Machine Learning we encounter.

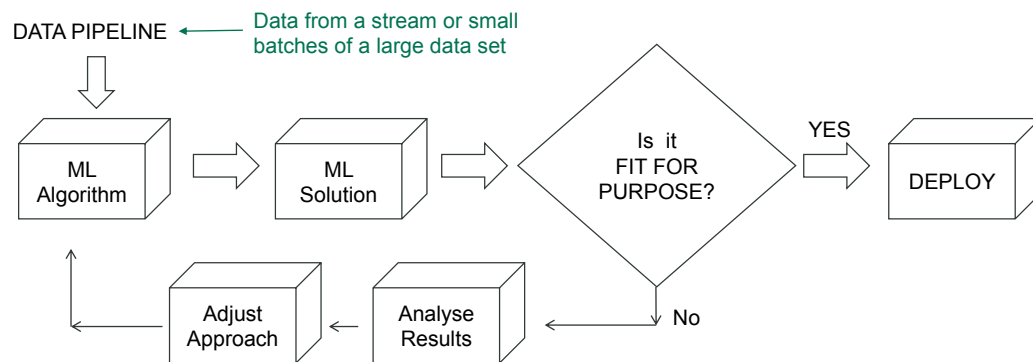
Explain what batch and offline learning is and when it is used.

Slide 86 – The types of Machine Learning

The types of Machine Learning

Online learning

- System learns in incremental steps with single, groups or small batches of data
- Useful for quickly changing data where the ML solution needs to adapt
- Useful for large datasets and where there are limited hardware resource



86

Online learning (this could mean on the www) – here it means the machine learning algorithm is always learning from data.

If there's a lot of data to analyse, we may break it up into small batches and feed it continually into the Machine Learning algorithm.

Slide 87 – The types of Machine Learning

The types of Machine Learning

Instance-based learning

- Is the simplest form of learning, often called learning by heart - example: times tables, spelling
- Can be made more general by building a similarity measure, unknown data can then be assessed to known measures - example: spam filter

Model-based learning

- Here, we build a model of the data (we choose the type of model)
- The model is used to make predictions
- Example: fit a straight line through experiment data and use the formula to make predictions

87

Here are two more ways to describe Machine Learning.

Explain what they are and ask the delegates for examples.

Slide 88 – Machine Learning is multi-disciplinary

Machine Learning is multi-disciplinary

Machine Learning is taught in computer science at all levels of education. It involves:

- Artificial Intelligence – Building Intelligent Entities (more than just working on data)
- Mathematics – statistics and probability, operational research, numerical analysis (numerical solutions rather than symbolic manipulation)
- Engineering
- Information theory – data and computer scientists
- Philosophy
- Control theory
- Psychology
- Neurobiology
- Business and management science
- Economics

Stuart Russell & Peter Norvig – ‘AI is relevant to any intellectual task: it is truly a universal field.’

88

Machine Learning is a very important part of AI. It's fundamental.

This slide is used to emphasise that it is multi-disciplinary, and an AI project will need to draw on a team.

Mention that Russell and Norvig say that AI is a truly universal field.

Slide 89 – Machine Learning – good data and algorithms

Machine Learning – good data and algorithms

ML data:

Insufficient quantity of data (e.g. a child can recognise vegetables with a few prompts and then identify variations almost effortlessly)

- ML needs lots of data, not a few examples but 1,000,000s and 1,000,000s!
- Algorithms tend to perform better with the more data you have – Peter Norvig et al., 2009.
- Algorithms tend to converge on the right answer with enough data, provided they are fit for purpose.

The wrong data set (e.g. teach a child about sponges and expect them to identify a face cloth)

- ML needs data that is representative of the problem you are learning about.
- ML can suffer from BIAS (sample data from the wrong group).

A poor data set (e.g. teach a child the wrong answers to times tables)

- ML need data that does not contain lots of errors, randomness or noise, extremes.
- ML needs data that does not contain irrelevant features.

89

Machine Learning is a good place to start developing a learning system.

This slide is about getting good Data and list some of the problems with bad data.

Ask the delegates of their experience of working with bad data.

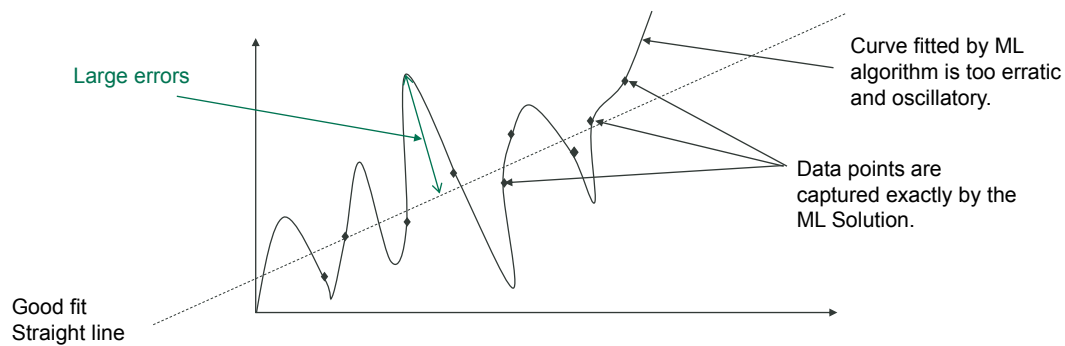
Slide 90 – Machine Learning – good data and algorithms

Machine Learning – good data and algorithms

ML algorithms – we need good algorithms that don't suffer from:

Overfitting (e.g. a child is knocked over by a small cat and thinks all animals are clumsy.)

- It works well on the training data but not so well on general data.



90

Algorithms are also a fundamental part of ML. One of the common issues with an algorithm is overfitting.

Explain what this is and how we might mitigate this effect.

The curvy or oscillatory line tells a numerical analyst that the curve is overfitted. The real data would be better represented by a straight line.

Slide 91 – Machine Learning – good data and algorithms

Machine Learning – good data and algorithms

ML algorithms – we need good algorithms that don't suffer from:

Overfitting – (e.g. a child is knocked over by a small cat and thinks all animals are clumsy)

- It happens when the algorithm is too complex and overly sophisticated.
- Reduce the complexity of the algorithm.
- Reduce the number of attributes in the training data.
- Use more training data.
- Reduce the noise in the data (remove outliers that can distort the result).
- Constrain the model, make it simpler and limit the amount of overfitting.

91

This slide adds more of a description of what overfitting is.

Highlight some of the possible ways we can fix this.

Ask the delegates if they can suggest ways of fixing this.

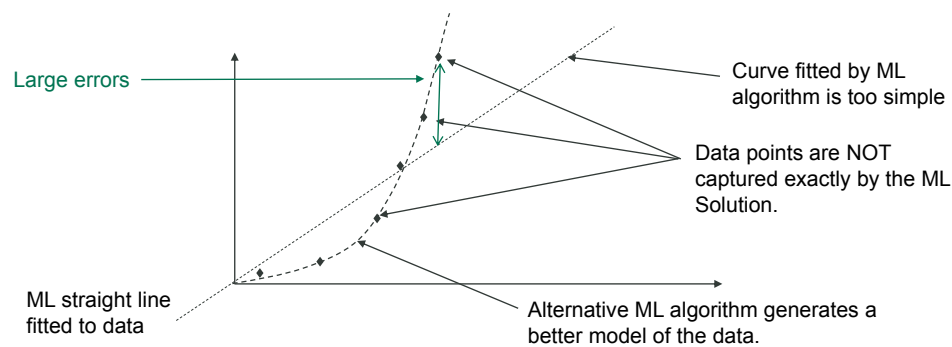
Slide 92 – Machine Learning – good data and algorithms

Machine Learning – good data and algorithms

ML algorithms – we need good algorithms that don't suffer from:

Underfitting (e.g. a child is taught what food is then asked to pick out a red apple)

- It means the ML algorithm has built a model that is too simple.



92

This slide is about underfitting.

Explain what this is. Put simply, our ML system is overly simplified. You can see this from the parabolic form of the data. Simply fitting a straight line is clearly not correct!

Ask the delegates if they can suggest an alternative fix.

Slide 93 – Machine Learning – good data and algorithms

Machine Learning – good data and algorithms

ML algorithms – we need good algorithms with the best hyper-parameters:

Hyper-parameters are high-level descriptions of the ML and model we are training with the data:

- Fixed at the start of the training of the ML algorithm
- Cannot be determined from the dataset
- Need to be systematically tuned to obtain the best learning results

Examples are:

- Number of layers in a neural net
- Size of the dataset to train on
- Depth of a decision tree

93

Explain that ML algorithms have their own hyper-parameters that can be used to improve how they learn.

Explain that when training an ML algorithm, we must be systematic in how we train it so we obtain the best learning results.

Slide 94 – Example exam question

Example exam question

What is hard to transform into value, requires specialist technology to learn from because it has large amounts of high volume, high velocity and variety of data?

- (a) Weather simulations.
- (b) Tax returns.
- (c) World economy.
- (d) Big Data.

Answer: ?

94

The answer is (d). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 95 – Example exam question

Example exam question

What famous paper did Alan Turing write in 1950?

- (a) 'Computing machinery and intelligence'.
- (b) 'Can systems think?'
- (c) 'Can computers think?'
- (d) 'Robots of the future'.

Answer: ?

95

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 96 – Example exam question

Example exam question

Optical Character Recognition (OCR) uses Machine Learning to interpret...

- (a) Images of handwriting and text.
- (b) Images.
- (c) Technical drawings.
- (d) Road signs.

Answer: ?

96

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 97 – Example exam question

Example exam question

What does NLP stand for?

- (a) National Language Process.
- (b) Natural Language Processing.
- (c) Natural Linear Processing.
- (d) Non-Linear Programming.

Answer: ?

97

The answer is (b). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 98 – Example exam question

Example exam question

What type of data does Semi-supervised Machine Learning use?

- (a) Labelled and un-labelled.
- (b) Random.
- (c) No data.
- (d) Expert System Data.

Answer: ?

98

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 99 – Example exam question

Example exam question

Swarm Intelligence and optimisation are used in what type of Machine Learning?

- (a) Revision Learning.
- (b) Repeat Learning.
- (c) Reinforcement Learning.
- (d) Reflective Practice Learning.

Answer: ?

99

The answer is (c). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 100 – Example exam question

Example exam question

Who is not part of a Machine Learning project team?

- (a) Data scientist.
- (b) Computer scientist.
- (c) Questionnaire specialist.
- (d) Statistician.

Answer: ?

100

The answer is (c). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Slide 101 – Example exam question

Example exam question

Which of the following are a major risk to a Machine Learning project?

- (a) No objective.
- (b) No business benefit or strategic alignment.
- (c) Unsuitably qualified and inexperienced staff.
- (d) All of the above.

Answer: ?

101

The answer is (d). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Exercise Two


Maturity and funding of an AI system

Slide 102 – Explore some of the key questions when assessing the maturity and funding of an AI system

Exercise Two

Maturity and funding of an AI system

Explore some of the key questions when assessing the maturity and funding of an AI system

102

See Exercise book. Exercise Two – Maturity and Funding of an AI System

Objective: Allow participants to explore their first AI project(s) in terms of what is involved and how to measure the maturity of the technology.

Tutor facilitated:

1. Allow the participants to explore the table and fill it in for about five minutes.
 - Explain what functionality is. Get the participants to assess if there is software out there to do their learning and assess if the hardware is available to undertake the project. Mention that they also need to understand who's going to pay for it!
 - Explain what the TRLs – Technology Readiness Levels are:
http://www.earto.eu/fileadmin/content/03_Publications/The_TRL_Scale_as_a_R_I_Policy_Tool_-_EARTO_Recommendations_-_Final.pdf
2. When everyone has attempted the table, go around each participant and ask them to highlight their main learning point.
 - Allow brief discussion but avoid indulging in excessive debate.
 - Key is to build confidence in starting to define an AI project and develop a fuller understanding of what it takes to define an AI project. This exercise builds on Question 5 from Exercise One and is about defining that first AI project.

Session 6

The future of artificial intelligence

– *human and machine together*

Slide 103 – Title slide

Session 6

The future of artificial intelligence

– *human and machine together*



BCS Essentials Certificate in Artificial Intelligence Courseware

103

Slide 104 – Human plus machine

Human plus machine

How do we re-imagine every aspect of our lives with AI?

This is elegantly described by Paul R. Daugherty and H. James Wilson in their book, *Human Plus Machine*.

Harvard Business Review – Accenture Management Consultants

So we can exploit the Fourth Industrial Revolution

Charles Schwab – Founder and executive chair of The World Economic Forum

Ethically – understanding the subjective conscious part of being human

Life 3.0 – Max Tegmark – Founder of Future of Life Institute & The Science of Consciousness – Prof David Chalmers

104

This slide introduces the idea of humans, machines, and humans and machines together.

Describe that we will explore what humans are good at and what machines are good at, and that there is an area where humans and machines can augment each other.

ETHICS is missing and we address this here.

Remind the delegates that AI can help us take advantage of the Fourth Industrial Revolution.

Slide 105 – Ethics

Ethics

We want to take advantage of opportunities ethically – NOT easy to define but the good news is that we are working on it. Examples for AI in general are:

<https://www.fhi.ox.ac.uk/>

Oxford, UK

<https://www.partnershiponai.org>

Leading commercial providers

<http://lcfi.ac.uk>

Cambridge and Imperial, UK & Berkeley, USA

<https://intelligence.org>

Berkeley, USA

UK EPSRC has developed guidelines for the ethics of robotics:

<https://epsrc.ukri.org/research/ourportfolio/themes/engineering/activities/principlesofrobotics/>

ISO and IEC have begun industrial standards development:

<https://iecotech.org/Technical-Committees/2018-03/First-International-Standards-committee-for-entire-AI-ecosystem>

105

Start with ethics and how we take advantage of opportunities ethically. There has been a large push on ethical understanding from 2015 onwards.

Give examples and make the link between ethics and human consciousness.

Slide 106 – Robotics guidelines EPSRC

Robotics guidelines EPSRC

5 principles and 7 high-level messages to encourage responsibility

- Broken down into a legal, general audience and commentary

General audience principles

1. 'Robots should not be designed as weapons, except for national security reasons.'
2. 'Robots should be designed and operated to comply with existing law, including privacy.'
3. 'Robots are products: as with other products, they should be designed to be safe and secure.'
4. 'Robots are manufactured artefacts: the illusion of emotions and intent should not be used to exploit vulnerable users.'
5. 'It should be possible to find out who is responsible for any robot.'

106

Describe the EPSRC's general audience principles for robots.

Slide 107 – Ethics in AI

Ethics in AI

General background:

https://en.wikipedia.org/wiki/Ethics_of_artificial_intelligence#Machine_ethics

Common theme:

Open and transparent → Open Source Code.

Do no harm.

The culture in AI research and AI community is now developing AI for good:

- Just like chemists make medicine not poison.
- Engineers continually make cars safer, less polluting...

BUT: What happens if Super AI develops consciousness – WE DO NOT KNOW

107

Explore with the candidates the common themes in AI Ethics and that guidelines are being written but it takes a long time because they have to be written into law.

So far, we've only considered rational or unemotional AI – suggest the delegates think about what happens if AI is developed into super AI!

Slide 108 – Human consciousness

Human consciousness

Philosophical subject – studied for centuries (René Descartes (1596–1650): 'I think therefore I am.')

It is subjective and depends on the individual.

Professor David Chalmers has broken this down into Easy and Hard Questions of Consciousness.

Easy Consciousness Question: Explaining the ability to discriminate, integrate information, report mental states, focus our attention, etc ...

Hard Consciousness Question: The hard problem of consciousness is the problem of experience. https://en.wikipedia.org/wiki/Hard_problem_of_consciousness

Synthetic consciousness, Artificial General AI and Robotics are NOT going to help us with the hard problem any time soon and even if we did solve it, David Chalmers thinks it might be confusing, a bit like quantum theory!

108

Super AI will have consciousness (we don't know if it is possible).

Explain that consciousness in AI is speculative and we should prepare for it, even though it's not likely soon.

Describe Prof David Chambers Easy and Hard Questions of Consciousness.

Slide 109 – Humans provide the subjective

Humans provide the subjective

René Descartes (1596–1650): ‘An optimist may see a light where there is none, but why must the pessimist always run to blow it out?’

Benjamin Franklin (1706–1790): ‘Tell me and I forget. Teach me and I remember. Involve me and I learn.’

Daugherty and Wilson (*Human Plus Machine*):

- Human roles
- Hybrid human plus machine roles
- Machine roles

Max Tegmark (*Life 3.0*):

- Humans ensure AI is aligned with human goals.

109

Describe what Humans can bring to the human and machine partnership – the subjective, emotional empathic understanding and learning.

The key point is that humans make the ethics human centric, the goals of our AI are aligned with Human goals.

Slide 110 – ‘Humans only’ roles

‘Humans only’ roles

From Daugherty and Wilson:

- Leadership
- Ethics
- Judgement
- Creativity

110

Describe the typical human roles from Daugherty and Wilson

Slide 111 – Humans complement machine by ...

Humans complement machine by ...

Training – e.g. teaching AI systems to adapt to us, how to do a task, both individuals and groups teaching AI

Explaining – e.g. explaining why a black box AI system is acting the way it is especially when it goes against conventional wisdom

Sustaining – e.g. limiting the application of AI (including robotics) based on legal, sustainability or ethical compliance. IT'S NOT JUST A BUSINESS CASE.

From Daugherty and Wilson

111

Describe the typical ways humans complement machines from Daugherty and Wilson.

Slide 112 – AI enhances humans by ...

AI enhances humans by ...

Amplifying – Extraordinary data insight, searches the web in seconds, optimises engineering design, fast diagnosis of medical issues for doctors

Interacting – personal assistant roles in customer service, FAQs on helplines – LEAVES humans to deal with awkward ambiguous problems

Embodying – works in physical spaces via sensors, motors, actuators, robots for collaborative work with humans

From Daugherty and Wilson

112

Describe how AI enhances humans from Daugherty and Wilson

Slide 113 – Humans drive the change

Humans drive the change

Humans are a fundamental and integral part of re-imagining our life with AI, they:

- Set the goals.
- Set the ethics.

Deep Neural Networks have boosted Machine Learning capability.

General AI, Consciousness AI, Subjective AI are unknowns – we are not sure what the future holds.

In the short to medium term – we can become more human as we embrace AI and the Fourth Industrial Revolution.

113

Explore what humans will do in the new era of AI in the Fourth Industrial Revolution.

Daugherty and Wilson claim we will become more human.

Stuart Russel says our future will be humans looking after other humans.

Slide 114 – Asilomar principles

Asilomar principles

‘Our Call to Action – Re-imagining every aspect of our lives with AI’

The Beneficial AI Conference 2017 developed the Asilomar principles for AI. There are 23 principles relating to:

Research

Goals, funding, policy, cultures, race avoidance (speed of progress)

Ethics and values

Safety, failure transparency, judicial transparency, responsibility, value alignment, human values, personal privacy, liberty and privacy, shared benefit, shared prosperity, human control, non-subversion, AI arms race

Longer term issues

Capability caution, importance, risks, recursive self-improvement, common good

114

Ethics is being driven by one international organisation in particular.

Explain the history of the Asilomar principles.

Mention that researchers and organisations are signing up to these principles.

Slide 115 – Get the KASH

Get the KASH

‘Our Call to Action – Re-imagining every aspect of our lives with AI’

Knowledge Start ‘learning from experience’, with some AI ML help.

Attitude The right attitude determines the outcome.

Skills Develop the skills (e.g. Agile Project Management – ‘learning from experience’ at its heart).

Habits Make these habits.

115

Recap the session based on our Call to Action.

Slide 116 – Example exam question

Example exam question

Artificial Intelligence, machines and humans will develop a new, exciting future by...

- (a) Learning to complement each other.
- (b) Specialising in one focused task.
- (c) Building a new society, one for machines and one for humans.
- (d) Allowing machine ethics to drive human ethics.

Answer: ?

116

The answer is (a). Explore the distractor answers with the group. Don't spend too long and let the group wonder.

Exercise Three


Re-imagining the future opportunities for AI and human systems

Slide 117 – Explore some of the key questions of what the future holds for human and machine augmented systems

Exercise Three

Re-imagining the future opportunities for AI and human systems

Explore some of the key questions of what the future holds for human and machine augmented systems

117

See Exercise book. Exercise Three – Re-imagining the Future Opportunities for AI and Human Systems

Objective: Allow participants to explore the future of AI and define a futuristic AI project. In doing so, start to build an understanding of where humans, machines and humans in combination with machines will be best suited to achieve a goal.

Tutor facilitated:

1. Spend a minute allowing the participants to develop an idea or ideas.
2. When everyone has attempted each question, go through them allowing each participant to give a quick overview of their answers.
 - Allow brief discussion but avoid over indulging in excessive debate.
 - Key is to build confidence in starting to define a futuristic AI project.
 - Remind people that AI is about building intelligent entities – where's the 'learning from experience'?
 - Remind people that humans and machines will work together (machines take up the heavy lifting) and that there will no doubt be ethical issues we will need to address!


Session 7

Conclusion and reading list

Slide 118 – Title slide

Session 7

Conclusion and reading list



BCS Essentials Certificate in Artificial Intelligence Courseware

118

This is the final session.

Slide 119 – What have we learned?

What have we learned ?

- The history of AI
- The definition of AI
- The focus on Machine Learning
- ML project basics
- Benefits, challenges, risks
- The future of human + machine

119

What we have learned. General recap, no specifics

Slide 120 – What was in it for me?

What was in it for me?

- Artificial and human intelligence – an introduction and history
 - Exercise One: Opportunities for an AI system
- Examples of AI – benefits, challenges and risks
- An introduction to Machine Learning
 - Exercise Two: Maturity and funding of an AI system
- The future of artificial intelligence – human and machine together
 - Exercise Three: Re-imagining the future opportunities for AI and human systems

120

Explain what was in the course that will help their future AI projects and development.

Slide 121 – Journey home – so what?

Journey home – so what?

- The Fourth Industrial Revolution will make us re-imagine every aspect of life.
- It is about 'learning from experience' – Building Intelligent Entities
- It is NOT a Silver Bullet.
- Machine Learning needs good quality DATA and good algorithms.

121

Another recap of the main themes in the course – what the delegates can tell colleagues or family they learned on the course.

Slide 122 – Reading list

Reading list

Artificial Intelligence and Consciousness

Artificial Intelligence, A Modern Approach, Third Edition, Stuart Russell and Peter Norvig, 2016, ISBN-10: 1292153962

The Cambridge Handbook of Artificial Intelligence, Keith Frankish and William Ramsey, 2014, ISBN: 9780521691918

The Conscious Mind, David Chalmers, 1996, ISBN: 9780195117899

Life 3.0, Max Tegmark, Penguin Books, 2017, ISBN: 9780141981802

Machine Learning

Machine Learning, Tom Mitchell, 1997, McGraw-Hill. ISBN-10: 0071154671.

High-Level Management Consultants' View

The Fourth Industrial Revolution, Klaus Schwab, Penguin Random House, 2016, ISBN: 9780241300756

Human + Machine – Re-imagining Work in the Age of AI, Paul R. Daugherty and H. James Wilson, Harvard Business Review Press, 2018, ISBN-10: 1633693869.

122

Go through the reading list book by book.

Give the delegates an idea of what to expect from these books.

Slide 123 – Reading list

Reading list

Get Started on Machine Learning

Machine Learning For Absolute Beginners: A Plain English Introduction (Second Edition), Oliver Theobald, 2017, ISBN-10: 1549617214.

High Level Research and Political View of Machine Learning

<https://royalsociety.org/topics-policy/projects/machine-learning/>

Professional Development of Machine Learning Algorithms and Planning

Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Aurélien Géron, O'Reilly, 2017, ISBN-10: 1491962291.

Machine Learning – A Probabilistic Perspective, Kevin P. Murphy, MIT, 2012, ISBN-10: 0262018020

123

Go through the reading list book by book.

Give the delegates an idea of what to expect from these books.

Slide 124 – Additional reading list

Additional reading list

A Classic Best-seller Book on the Future

The Singularity is Near, Ray Kurzweil, Duckworth Overlook, 2005, ISBN: 9780715635612

Software Development Classic Text

The Mythical Man Month, Frederick P. Brooks, JR., Addison Wesley, 1995, ISBN-10: 0201835959

High-Level Marketing and Social Media Consultants' View

Artificial Intelligence: 101 Things You Must Know Today About Our Future, Lasse Rouhiainen, CreateSpace Independent Publishing Platform, 2008, ISBN-10: 1982048808.


124

Go through the reading list book by book.

Give the delegates an idea of what to expect from these books.

Slide 125 – The Exam

The Exam



BCS Essentials Certificate in Artificial Intelligence Courseware

125

The Exam