BEGINNERS' ARTIFICIAL INTELLIGENCE AND PYTHON PROGRAMMING

FOR PRIMARY AND JUNIOR SECONDARY SCHOOLS

(GRADES 4-8)

Beginners' Artificial Intelligence and Python Programming

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This book is powered by the vision of Data Science Nigeria
to raise 1 million Artificial Intelligence talents in 10 years

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GLOBAL REVIEWS

"Bayo Adekanmbi is a passionate communicator of his mission for Data Science Nigeria. This book for beginners explains many key concepts of artificial intelligence, with an informal style and engaging illustrations that speak directly to learners in Africa. He clearly explains basic principles of the Python programming language, so that students wanting to learn more about future opportunities in data science can start to become comfortable with the tools they need to use."

Professor Alan Blackwell - Director of Research, University of Cambridge's Global Challenges Initiative, United Kingdom

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"Artificial intelligence with python programming does not seem like a beginner's topic. But it is completely possible, as presented beautifully in this wonderful book. It will also be validated in the real-world successes that this book will inspire. The approach presented here is perfect, by firstintroducing interesting, useful, and impactful applications, outcomes, and use cases. This goal-oriented style will motivate students to learn more and do more with the combined power of AI and coding. This is absolutely essential for young people growing into this intensely digital and massively data-driven world. Every instructor and student should study this book!"

Dr. Kirk Borne, Principal Data Scientist and Data Science Fellow at Booz Allen Hamilton, USA

As we embark on the uncharted Fourth Industrial Revolution, the open question is, what contributions will come from Nigeria, Africa, or the developing world? Olubayo Adekanmbi's book provides one crucial pathway. Focusing on young people, it addresses systemic barriers to entry by creating a level playing field for girls and boys to acquire knowledge of python programming and other nuances of AI. Furthermore, the use of relatable, local, age-appropriate illustrations makes it easy for them to imbibe the concepts and philosophical underpinnings of coding. Thus, we can envision future localized AI-Solutions that will transform societies and improve lives of the vulnerable and forgotten.

Dr. Uyi Stewart, Executive Director, AI Commons; previously, Director, Strategy, Data & Analytics, Bill and Melinda Gates Foundation, USA

"Artificial Intelligence (AI) is no doubt changing the world at exponential speed. It is changing everything around humanity. From adaptive learning to predictive analytics and natural language processing, AI is fundamentally shifting how we live and relate with one another. At the same time, virtually every economy is digitalizing. To cope with these emerging changes every citizen including children must be digital-ready. Children especially must learn code at an early age to build logical thinking that is necessary for solving future problems. Olubayo Adekanmbi's book, Beginners' Artificial Intelligence and Python Programming, is just the right Africa needs now."

Prof Bitange Ndemo - Professor of Entrepreneurship, University of Nairobi and Chairman Blockchain and Artificial Intelligence Taskforce, Kenya.

"AI is the most transformative technology of our time. Hence, it is crucial to be understood and used by many across the world. Ideally, kids can understand AI early so it can shape their ideas about the future. This book is an excellent first step towards helping children understand AI and take their first steps with this technology"

Dr. Richard Socher - Chief Data Scientist, Salesforce, USA

GLOBAL REVIEWS

"As smart technology entrepreneur and AI expert that is driven by a massive transformative purpose to help shape a better future in the Smart Technology Era and helping to transform Africa, I highly recommend this excellent book by Olubayo Adekanmbi, as visionary founder of Data Science Nigeria, to introduce kids in their middle childhood to Artificial Intelligence and stimulate their curiosity to learn Python programming. Not only is the content presented in a very accessible, visual, and intelligible fashion, but really helps to also build an application-focused mindset. This book will go a long way to assist in effectively democratizing AI on the African continent and beyond."

Dr. Jacques Ludik - Founder & Executive Chairman, Cortex Group;
Founder & MD, Cortex Logic; Founder & President, MIIA, South Africa

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"Reskilling and relearning are critical ingredients for adaptation in the age of Artificial Intelligence. Starting early will definitely be a huge advantage. Olubayo Adekanmbi's book, Beginners' Artificial Intelligence and Python Programming, is a right start for young Africans now. The book is presented in a very conversational, visual, and activity-oriented fashion to simplify AI and Python programming. This book will complement other efforts to make Africa ready to compete in the fourth industrial revolution."

Brigette Hyacinth- Thought Leader in Leadership, HR, Artificial Intelligence (AI)
and Digital Transformation. Trinidad and Tobago

"One day, cars will drive themselves. You will use technologies that you can't even dream of today. Wouldn't that be cool?

"But wait," I hear you say. You don't just want to use those magical technologies. You want to CREATE them? You hold in your hands the Beginners' Artificial Intelligence and Python Programming book. It will guide you through the first steps of getting to know two tools that you'll need to CREATE those future technologies: artificial intelligence and programming. As you work through this book, you are joining a club of people who dream that those magical technologies would be invented and built in Africa. As of today, you are part of that ambitious dream!

Ulrich Paquet. Co-founder, Deep Learning Indaba and Research Scientist, DeepMind, UK.

"Artificial Intelligence, the technology that will define humanity's course in the 21st century, is often seen as a domain best left for experts or as an area of competition between the superpowers. In this formidable book, Olubayo Adekanmbi shatters these two notions by proving that AI can be taught to children in Africa. It is vital for our shared future that AI benefits everyone and no book that achieves this goal better than Olubayo's "Beginner's Artificial Intelligence and Python Programming".

Karim Beguir, Co-Founder and CEO, Instadeep UK

There is a palpable sense of urgency required for Africa to be in play for the Fourth Industrial Revolution by urgently and greatly enhancing human capacity (by enskilling and upskilling its people) in all the exponential technologies, especially with regards to AI. The book, 'Beginners Artificial Intelligence and Python Programming for Primary and Junior Secondary Schools", by Olubayo Adekanmbi, is going to be immensely useful in building capacity in AI, for African children, right from the primary schools.

Dr Evans Woherem, Chairman, Digital Africa

DEDICATION

This book is dedicated to my darling wife, Toyin, who continues to be the back-end engine powering our collective success; to Bolu and Folu, our angels, who lovingly share in our hopes, passion and aspiration to contribute to making the world a better place; and to the many friends, partners, sponsors, advisory board members, community members and Data Science Nigeria staff, who passionately go the extra mile with us.

Thank you all.

PREFACE

The years 2015 and 2016 formed a major milestone in my life. I took a sabbatical from my full-time work and undertook academic research towards earning my PhD in London, which required frequent trips to many emerging markets as I worked on a cross-country data science project that focused on bandwagon social consumption behaviour. One of the major take-aways for me was the huge potential in emerging markets, particularly in Nigeria, and that we can accelerate tech-enabled development through pervasive knowledge, particularly in high-impact areas of social good. This was the starting point of my goal to raise one million talented artificial intelligence (AI) specialists in Nigeria during the next 10 years through a non-profit I started about three years ago, Data Science Nigeria.

As the realities of the Fourth Industrial Revolution become evident, AI will become one basis for national competitiveness. Hence, it is imperative for Nigeria to build an AI-first society in which artificial intelligence is effectively deployed to solve local problems, particularly in addressing the country's sustainable development goals. This hinges on the established fact that AI can, and will, provide a springboard for Africa's development by enhancing how we live, work and play.

By creating pervasive knowledge across the country, we will open opportunities for every Nigerian to build the skills of the future. I believe that Nigeria's population of 200 million, with its median age of about 18 years, is a huge strategic advantage that will position Nigeria as one of the top 10 AI knowledge centres in the world, especially if we proactively re-tool and reskill our young ones with relevant skills that can drive increased employability, foreign exchange inflows, AI-enabled start-ups, and enhance the general quality of life through solution-oriented AI applications in health, agriculture, financial inclusion, smart cities, and more. This will greatly benefit the lives of Nigerians, starting with those who train as data scientists and artificial intelligence specialists.

This book is an effort towards AI knowledge democratization as it simplifies the concept of artificial intelligence in a friendly manner to our students, with a view to stimulating their curiosity and their interest in learning about AI. The book starts with generic introductions to the core concepts including machine learning, deep learning and reinforcement learning, and then introduces step-by-step programming using the Python programming language. My intention is to go beyond the traditional code-first approach and motivate readers by helping them to understand what the knowledge of coding can do for them, particularly in AI, as a way to build an application-focused mindset.

I appreciate all the friends, sponsors, advisory board members, partners, volunteers and staff of Data Science Nigeria, who continue to support the vision of solution-oriented applications of AI for Nigeria's collective good. I appreciate my ever-inspiring colleagues at MTN and fellow kingdom labourers at TACEF.

Thank you, Mobolurin (Bolu) and Mofolusayo (Folu) Adekanmbi, for painstakingly going through the writing and the codes, line by line, to ensure its full compliance with the language and imagery relevant to the book's intended audience.

Olubayo Adekanmbi

Lagos, Nigeria

What is Artificial Intelligence?

In this chapter, we are going to learn about:

- ✔ what Artificial Intelligence, or AI, is;
- ✔ how AI is changing the world

Hello everyone!
In this chapter, we are going to explore the wonderful world of AI!

Yes! The world of AI is very exciting! Did you know that because of AI, by the time you become an adult, it is likely that you won't have to drive a car yourself? This is because the roads will be full of cars that drive themselves.
Now isn't that cool?

Fun Facts

Did you know that there are cars that can drive themselves?

Cars that can drive themselves are called 'self-driving cars', 'autonomous vehicles' or 'robocars' and they all use AI to do so.

Companies have been building and testing self-driving cars that use AI for many years. In December 2018, a company called Waymo started a taxi service using self-driving cars to give rides to people in the suburbs of Phoenix, USA.

People are excited about the many benefits that self-driving cars will bring, such as:

- fewer accidents
- fewer traffic jams
- less fuel
- more time for people to do other things, as they can work, read or sleep in the car while the car drives itself!
- fewer traffic police are required on the road since self-driving cars will obey the rules of the road.

Wow!
Self-driving cars sound awesome!
I can't wait to ride in one!

What Is Artificial Intelligence?

We have learnt that self-driving cars are able to drive themselves using Artificial Intelligence (AI)...but what does AI actually mean?

Techopedia defines Artificial Intelligence as:

'an area of computer science that emphasizes the creation of **intelligent machines that work and react like humans**. Some of the activities computers with artificial intelligence are designed for **include speech recognition, learning, planning and problem solving**.'

(source: https://www.techopedia.com/definition/190/artificial-intelligence-ai)

Now that you know what AI means, can you think of any examples of AI that affect your daily life?

Applications of Artificial Intelligence

- **Smartphones**: When you use a **smartphone** (such as an Apple iPhone, Samsung or Huawei), you are interacting with AI. Virtual assistants on smartphones, such as Siri on iPhones and Bixby on Samsung, use AI to perform tasks and services for us. Siri uses speech recognition to answer questions, provide directions and set reminders. The virtual assistants on our smartphones are there to make our lives easier.

Did you know that Siri not only helps you to manage your day-to-day life, but she also has a sense of humour, just like a human? Ask her a silly question and see what her answer is.

Fun Facts

Can you remember the definitionof AI? The definitionsays that AI involves intelligent machines that 'work and **react like humans**'.

One of the ways that iPhone's virtual assistant, Siri, behaves like a human is by displaying a sense of humour. For example, if you ask Siri the question, 'Are you a robot?' she will respond with an answer like:

- 'Virtual assistants have feelings too, you know'; or
- 'The humanoid mind. You are inquisitive'!.

You could also ask Siri, "Are you intelligent?" and her answer might be something like:

- 'I'm smart enough to know not to answer that question', or
- 'As intelligent agents go, I'm not too shabby'.

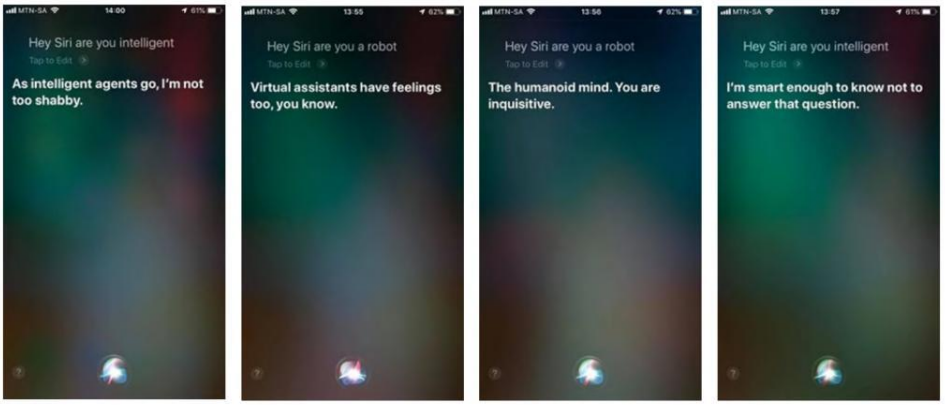
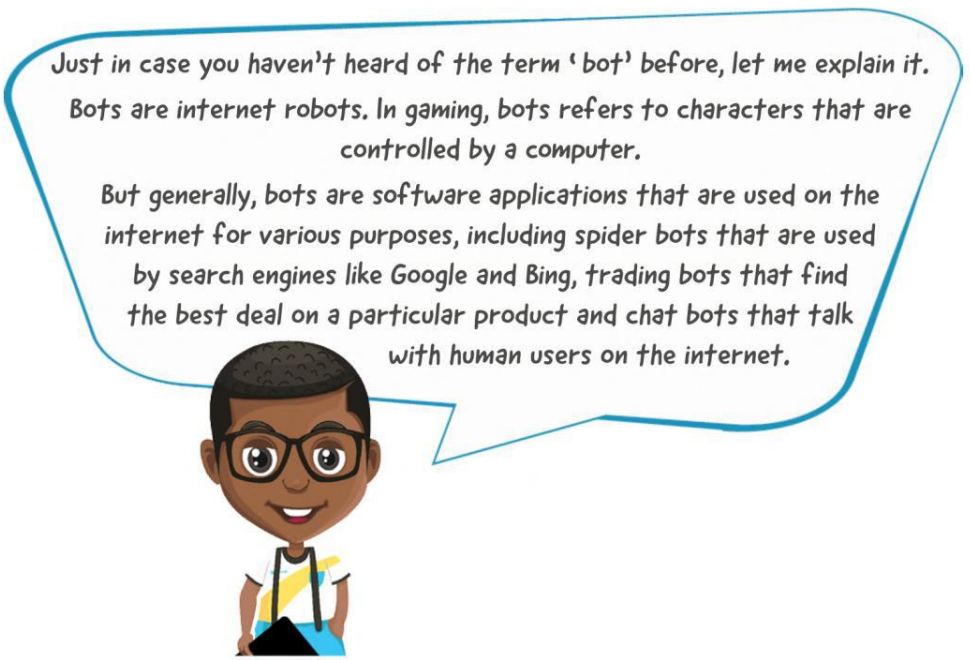


Figure 1:1 – Display screen showing how Siri responds to questions

- **Video Games**: AI has been used in **video games** for many years. When you start playing a game such as Fortnite, you first play against an AI-powered bot before playing against real people. AI examines the human player's behaviour and then adjusts the bot's responses to make the game realistic, engaging and challenging.



- **Comfortable Living in Smarter Homes:** AI can be used to make the homes that we live in more comfortable. Some people already live in homes where they use voice-activated AI systems, such as Amazon's Echo and Alexa, to dim lights, close blinds and lock the doors.

  Appliances, such as fridges, can be connected and controlled from a smartphone or tablet. For example, if your mom went shopping but forgot her grocery list, she could use her smartphone to look into the fridge at home and see what foods your family is running low on, and then decide what to buy at the grocery store.

  Mind-reading technology is also being developed, and in the future it could be used in your home to control appliances, such as turning down the volume on the television or closing the curtains.

Fun Facts

The AlterEgo headset is an example of mind-reading technology. It was created by a graduate student, Arnav Kapur, at Massachusetts Institute of Technology (MIT) in the USA. It is a 3D plastic headset that you attach to the side of your head.

When you wear the AlterEgo headset, you can control connected devices, such as turning on the lights, switching off the oven, ordering a pizza, solving maths problems, and flipping through TV channels, all without saying a word.

While it seems as if AlterEgo reads your mind, it actually doesn't. It works by picking up tiny electrical signals that your face and neck make when you silently talk to yourself. AlterEgo captures these tiny electrical signals and sends them to a computer that decodes them and then acts on them (e.g. it turns on the light).

Unfortunately, AlterEgo is not for sale. It is still a university research project that MIT is developing and refining.

Figure 1:2 - AlterEgo headset worn by its inventor, Arnav Kapur
Source: MIT News

- **Better Healthcare**: AI is already helping us to take better care of our health. AI is helping doctors to quickly and easily diagnose illnesses in patients, which allows them to treat patients more quickly and save more lives. AI is also helping doctors to predict what health problems a patient may have in the future by analysing data on the patient's genetic history, type of food the person eats, where the person lives, their age, etc.

  AI is being used to detect cancer in patients at a very early stage, and is helping doctors decide on the best cancer treatments for individual patients.

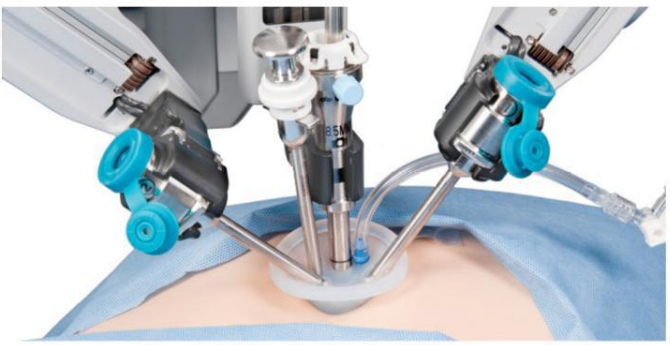


Figure 1:3 - How robots use artificial intelligence for surgery
Source: New York Times

- **Prediction of Natural Disasters**: AI can help us to predict natural disasters, especially storms and earthquakes. AI systems predict natural disasters by analysing years of data about storms, earthquakes and hurricanes. It can read the signs faster and predict what is likely to happen next.

- **Entertainment**: Companies such as YouTube and Netflix currently use AI to suggest videos that you might like to watch based on what you have previously watched. In the future, however, it is quite likely that you will be able to watch movies that feature your choice of virtual actors.

- **Improved Policing**: AI is helping police to catch criminals. In the UK, the police force uses a facial recognition system that helps them to spot a suspect just by analysing a small portion of person's face. In Spain, an AI system is being developed to examine photographs from crime scenes and identify evidence that may be linked to different crimes.

Figure 1:4 - How Robot Police is being used to track crimes in Dubai
Source: Gulf News

- **Fraud Monitoring**: AI helps financial companies (e.g. banks) to monitor transactions, spot patterns in a customer's transactions, then alert a customer when there is suspicious activity outside of the customer's usual transaction pattern. With this, banks can protect their customers against thieves, especially online thieves.

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Machine Learning: How Machine Learns from Patterns

In this chapter, we are going to learn about:

- ✔ patterns in AI.
- ✔ how AI uses patterns to make prediction.
- ✔ how AI learns from pattern and the past.

Join me and let's explore the wonderful world of patterns and predictions. That is, learning from what has happened in the past to predict what will happen in the future.

I can think of a pattern right now! I remember that each time Grade 5 and Grade 6 play football, there is a pattern of who wins and I think I know why! The Grade 5 football team always win when they play with their main goalkeeper, Adaeze, and only when the match is held on the old school pitch. Interesting, isn't it?

Everything around us seems to follow a pattern, and if we study these patterns carefully and especially regarding what has happened in the past, we can predict what will happen in the future. Here are some amazing patterns that we often take for granted.

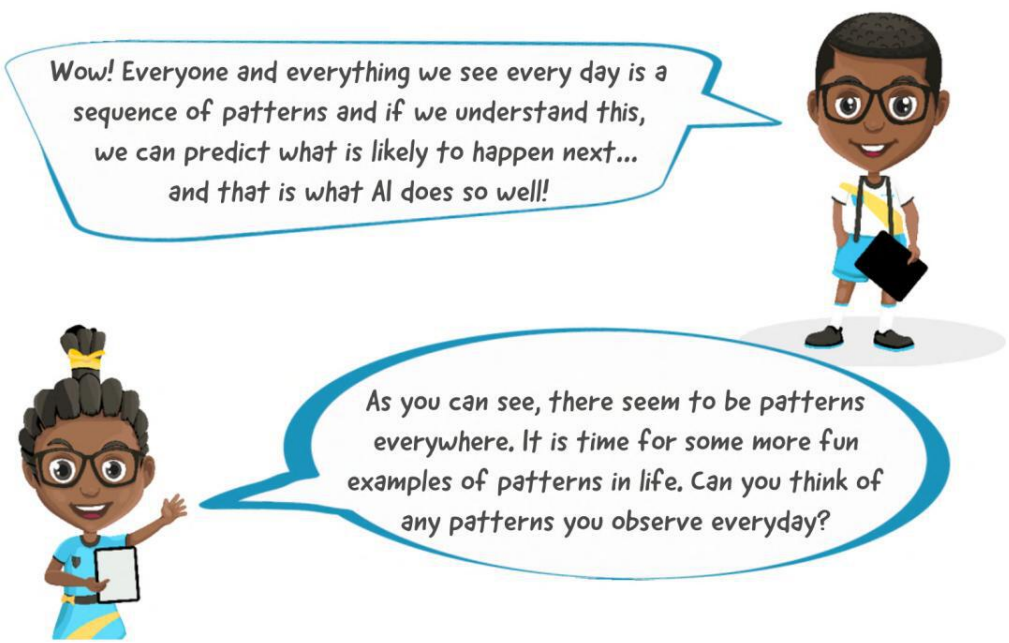
- The months when it tends to rain most are usually the same ones every year.
- It always gets dark at around 6:30 7pm, and a new day breaks at about 6:30am every morning.
- The daily news on radio and television tend to follow certain pattern (7am, 12 noon, 7pm and 10pm).

Patterns are everywhere around us. For instance, we use Google Maps for directions, and we usually prefer to take the shortest distance possible to get to our destination. Do you know how Google seems to know which is the best route to take? Well, over the years, as people use Google Maps to navigate, it keeps a record of the routes these people have taken and the time taken. As such, over time, Google Maps has learned to understand the traffic patterns of different routes. So, if you want to find the best route to your friend's house, Google Maps knows which route is likely to have the least traffic, so can tell you the best and quickest way to get there.

Figure 2.1 – How Google Maps learns from past route patterns
Source: UK Daily Express

Fun Fact

Scientists have shown that the average person blinks 15-20 times per minute. That's up to 1,200 times per hour and a whopping 28,800 times in a day—much more often than we need to keep our eyeballs lubricated. In fact, we spend about 10 percent of our waking hours with our eyes closed.



How Can a Machine Learn These Patterns?

Bassey, a grade 6 student, had plenty of action figure toys he had collected when he was small. One day, Bassey noticed that his little dog, Brown, liked hiding his toys in his sister Lynda's bedroom. Bassey was happy each time he found his missing toys, because Brown had a habit of hiding them in a place where Bassey could easily find them. Can you help Bassey build a robot to help him find his toys?

Figure 2:2 – How robots can help Bassey find his toys
Source: My Real Domain

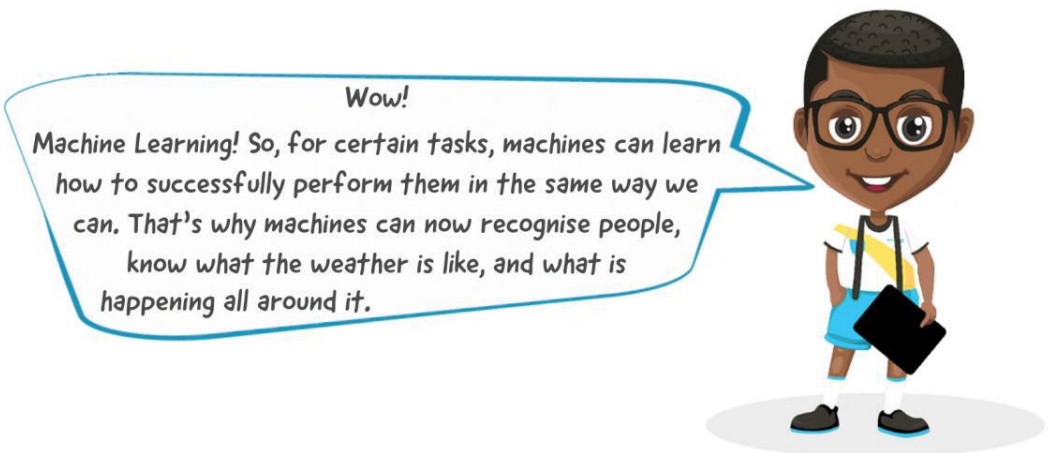
1. At first, the robot will have to learn what Bassey's toys look like (patterns). We will show the robot pictures of toys and then show the robot which toys belong to Bassey. When we do this, we say we are training the robot to understand patterns.
2. Also, we will train the robot to look for toys by looking under the bed, behind doors, in the wardrobe and in the closet.
3. Finally, we will do a test to see if the robot can find Bassey's toys.

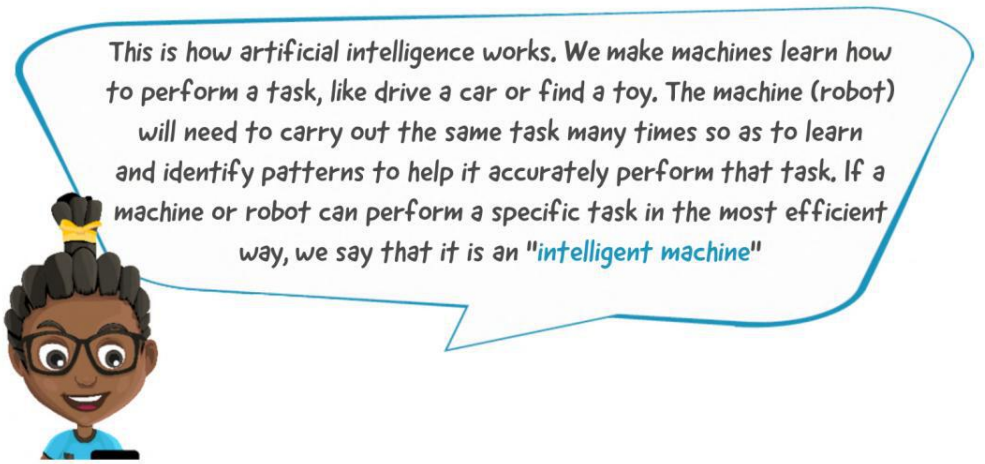
To make this more effective, if the robot succeeds, we reward it.

In many ways, the robot thinks just like a human. It will begin its search for the toys. Each time it looks in a place and finds no toys, it moves on to the next place, making a mental note where it has already looked. It will keep looking in different places until it finds all the toys.

The robot will perform the same search, time and time again, until it recognises that the toys are usually found in the same place, Lynda's bedroom, so it will then go straight to Lynda's bedroom to begin its search. After a few more searches it may then recognise that most times it finds a toy under the bed, so the next time it searches for the toys, it will go straight to Lynda's bedroom and look under the bed first, then in other places where it has found toys before.

This process by which something tries to understand a pattern it has not been previously been exposed to is called **LEARNING**. If a machine is being used for the learning process, we call it **MACHINE LEARNING!**





In the past, we have always given instructions to machines to get them to carry out certain tasks, but that is now changing. With AI, machines can now make their own decisions, just like humans. This is because, as humans, we store information about patterns in our brains, AI is also able to help machines store information, from which they can learn and act in ways that are similar to humans. With the help of AI, machines can recognise what is going on around them, think, feel and then act based on all the information they have gathered!

The way that we come to school to learn, and later we are tested on what we have learned, is similar to machine learning.

Remember the first time you learned the numbers 0-9? Your teacher made you write the numbers. Even though we all have different styles of handwriting (writing patterns), it is still possible to recognise numbers written by different people. Do you think we can teach a computer how to recognise a number (also called a digit)? Let us create our first artificial intelligence program that can recognise the digits 0-9.

We will use a free online tool found at https://machinelearningforkids.co.uk

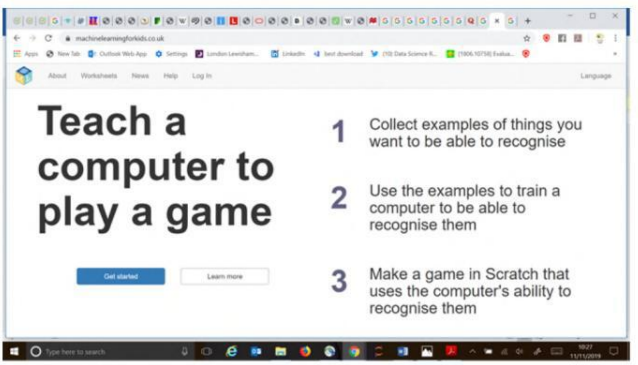


Figure 2:3 – How https://machinelearningforkids.co.uk looks like

Step 1: In order to train our machine, we start by collecting different handwritten digits from people, then we group them. You remember that learning patterns requires seeing many examples. So, all the number 1s are grouped together, then all the 2s, and we do this for every digit. The more examples we have (this is called training data), the better our machine will perform, and the more accurately it will operate.

Do you remember being introduced to a new topic in Mathematics? Your teacher will start by working through two or more examples. Similar to when our teacher gives us many examples to help us understand something new, we will be able to teach our machine to recognise handwritten digits by having many examples of handwritten digits grouped by their labels (in this case, what their number actually is).

Let's look at the examples below.

Figure 2:4 – Examples of handwritten digits for numbers 1, 2 and 3

We collect as many examples as possible because the more examples we have, the more accurate the ML program will be. Do you know what ML stands for? It means machine learning!

Step 2: Training is a way to learn patterns by using examples, in order to use the stored knowledge for future actions or predictions. So, after we have trained our ML model, it will be time to test it.

We are going to write a number (between 0-9) and ask the ML model we have built to tell us what number it is.

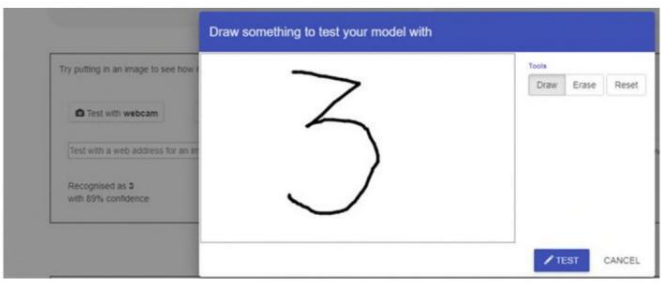


Figure 2:5 – Predicting handwritten digit for number 3

From the example above, our ML model was 89% sure it was correct. That is a good level of confidence. Sometimes ML models can be wrong, and then we then help them learn more. Look at the image below. It has only a 69% confidence score. Our ML model thought it was a 3 instead of a 2.

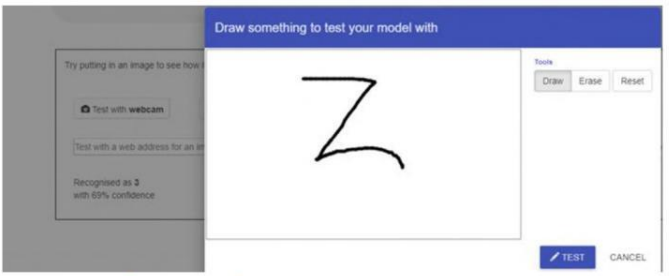
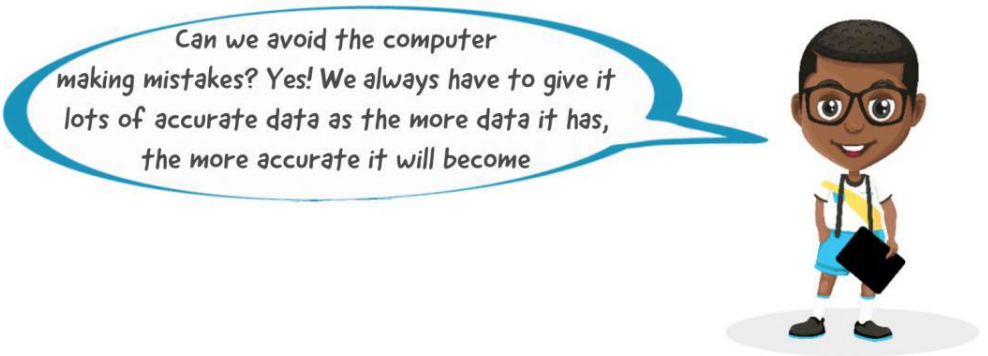


Figure 2:6 – Digit 2 wrongly recognized as digit 3



Teaching Your Model

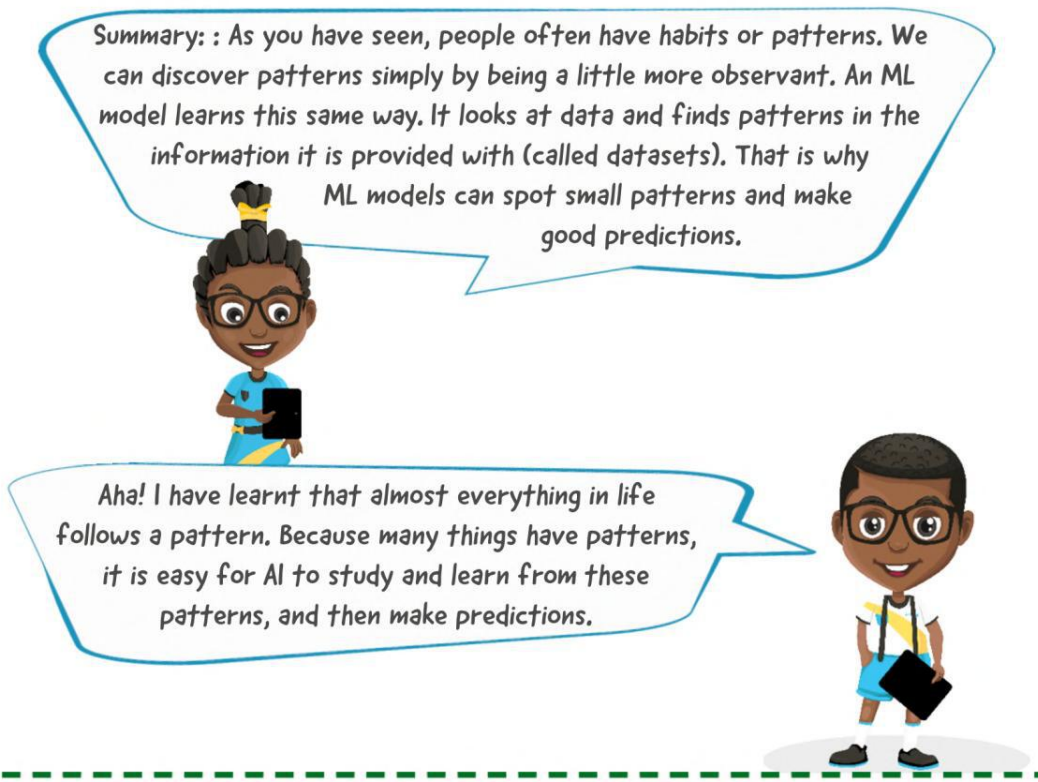
In the next example, let's say we want to teach a computer to recognise which books are good and which are bad. But the computer doesn't have eyes like we do and it can't read the title and content of each book in order to identify which books have irrelevant content and which books are inspirational and useful for learning purposes. So, what we do is to teach the computer by showing it many examples of books ("training data"), some of which are good ("positive examples") books, and some of which are bad ("negative examples").

For each category, we will also provide the computer with ways to describe the books; these are called **FEATURES**. For example, a book will be described using these features: its author, degree of academic relevance, curriculum suitability, and use of appropriate images.

Books	Known academic author	Degree of academic relevance	Curriculum suitability	Use of appropriate images	Good book or bad book
Believe	Yes	Yes	Yes	Yes	Good
Powered to Succeed	Yes	Yes	Yes	Yes	Good
Fire-Fire-Fire	No	No	No	No	Bad
Gra-Gra	No	No	No	No	Bad
BlackED	No	No	No	No	Bad
Chemistry 101	Yes	Yes	Yes	No	Bad
Lyricious	No	No	No	No	Bad

Now that we have given the computer the training data, it's the computer's job to learn a formula ('model') from it. The formula is like a special code that summarises all the patterns in the data. With this special code, each time the computer encounters a new book it can use the formula or model to decide whether the book is good or bad.

The way the computer makes this special code or formula to summarise the pattern it has observed is called **MODELING**. Let us explain how this is done. For each feature, a certain number of points ('weight') is assigned if it is a YES, but there will be few or no points if it's a NO. The model then sums up the points for a book to calculate the score. The model has a cut-off: if the score is above the cut-off, the model decides that the book is GOOD; if the score is below the cut-off, the model decides that the book is BAD.



Questions and Answers

Questions

- Is a computer able to spot objects in images?
- Do some things follow a pattern, or is everything random?
- Why are patterns so important in AI?

Answers

- Yes, most objects have patterns and computers can easily learn to recognize patterns.
- Many living things, especially humans, have patterns that make them predictable.
- AI can use patterns to recognize other patterns and make predictions for the future.

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