



COURSE TITLE: INTRODUCTION TO ARTIFICIAL INTELLIGENCE(AI) AND ROBOTICS

COURSE CODE: BRC-FUTO-U001

COURSE OUTLINE:

1. Definition of Artificial Intelligence

2. Brief history of AI

3. Branches of AI

4. Robotics

i. What is a robot?

ii. Brief history of Robotics

iii. Types of Robots

iv. Classification of robots base on its application

1. What is Artificial intelligence (AI)?



In 1956, John McCarthy coined the word Artificial Intelligence . He is also referred to as the father of Artificial Intelligence . John McCarthy gave a definition for the concept of AI as follows:

“Artificial Intelligence (AI) is the part of computer science concerned with designing intelligent computer systems, I.e.; systems that exhibit characteristics we associate with intelligence in human behavior – understanding language, learning, reasoning, solving problems, and so on. It is "the study of machines that receive percepts / signals from the environment and perform actions."

BREIF HISTORY AND EVOLUTION OF ARTIFICIAL INTELLIGENCE

In the 1940s and 50s, a handful of scientists from a variety of fields (mathematics, psychology, engineering, economics and political science) began to discuss the possibility of creating an artificial brain. The field of artificial intelligence research was founded as an academic discipline in 1956.

Turing's test

In 1950 Alan Turing published a landmark paper in which he speculated about the possibility of creating machines that think. He noted that "thinking" is difficult to define and devised his famous Turing Test. If a machine could carry on a conversation (over a tele printer) that was indistinguishable from a conversation with a human being, then it was reasonable to say that the machine was "thinking". This simplified version of the problem allowed Turing to argue convincingly that a "thinking machine" was at least *plausible* and the paper answered all the most common objections to the proposition. The Turing Test was the first serious proposal in the philosophy of artificial intelligence.

Game AI

In 1951, using the **Ferranti Mark 1** machine of the University of Manchester, **Christopher Strachey** wrote a checkers program and **Dietrich Prinz** wrote one for **chess**. **Arthur Samuel's** checkers program, developed in the middle 50s and early 60s, eventually achieved sufficient skill to challenge a respectable amateur. Game AI would continue to be used as a measure of progress in AI throughout its history.

a. Branches of Artificial Intelligence As AI Capabilities

There is a broad set of techniques that come in the domain of artificial intelligence such as linguistics, bias, vision, robotics, planning, natural language processing, decision science, etc. Let us acquire information about some of the major subfields of AI in deep;



Six major branches of Artificial Intelligence

I. Machine learning (ML)

In terms of advanced technology, one of the most demanded fields is Machine Learning, it is making buzz every day whenever a new product is introduced by any company that deploys ML techniques and algorithms for delivering the consumer in a highly creative manner.

- ML is the science that enables machines to translate, execute and investigate data for solving real-world problems.
- ML algorithms are created by complex mathematical skills that are coded in a machine language in order to make a complete ML system.
- ML enables individuals to execute tasks to categorize, decipher and estimate data from a given dataset.

II. Neural Networks

Incorporating cognitive science and machines to perform tasks, the neural network is a branch of artificial intelligence that makes use of neurology (a part of biology that concerns the nerve and nervous system of the human brain).

- Replicating the human brain where the human brain comprises an infinite number of neurons and to code brain-neurons into a system or a machine is what the neural network functions.

- Neural network and machine learning combined solve many complex tasks with ease.

III. Robotics

This has emerged as a very sizzling field of artificial intelligence. An interesting field of research and development mainly focuses on designing and constructing robots.

- Robotics is an interdisciplinary field of science and engineering incorporated with mechanical engineering, electrical engineering, computer science, and many others.
- Robotics determines the designing, producing, operating, and usage of robots. It deals with computer systems for their control, intelligent outcomes, and information transformation.
- Robots are deployed often for conducting tasks that might be laborious for humans to perform steadily.
- Major of robotics tasks involved- assembly line for automobile manufacturing, for moving large objects in space by NASA.
- AI researchers are also developing robots using machine learning to set interaction at social levels.

IV. Expert Systems

Expert systems were considered amid the first successful model of AI software. For the first time, they were designed in the 1970s and after that escalated in the 1980s.

- Under the umbrella of an AI technology, an expert system refers to a computer system that mimics the decision-making intelligence of a human expert.
- Expert systems are built to deal with complex problems via reasoning through the bodies of proficiency, expressed especially in particular of “if-then” rules instead of traditional agenda to code.

V. Fuzzy Logic

In the real world, sometimes we face a condition where it is difficult to recognize whether the condition is true or not, their fuzzy logic gives relevant flexibility for reasoning that leads to inaccuracies and uncertainties of any condition.

- Fuzzy logic is a technique that represents and modifies uncertain information by measuring the degree to which the hypothesis is correct.
- Fuzzy logic is also used for reasoning about naturally uncertain concepts.
- It is simply the generalization of the standard logic where a concept exhibits a degree of truth between 0.0 to 1.0. If the concept is completely true, standard logic is 1.0 and 0.0 for the completely false concept. But in fuzzy logic, there is also an intermediate value too which is partially true and partially false.

VI. Natural Language Processing

- Natural language processing depicts the developing methods that assist in communicating with machines using human languages such as English.
- NLP is the processing of the human language by computer programs, examples include; spam detection by looking at the subject of a line or text of an email and checking if it is junk.

- NLP tasks are text translation, sentiment analysis, and speech recognition. NLP is used by Twitter to percolate terroristic language from their tweets, by amazon to interpret user reviews and enhance user experience.

2. Importance / uses of Artificial intelligence AI

Below are the important uses of artificial intelligence and their prominence in this age and time underlines their importance:

A. In the field of Medical Sciences

- The artificial intelligence has made a phenomenal impact in the medical industry and therefore changes the face of the medical industry. There have been various machine learning algorithms and models that have been working efficiently to predict various critical use cases such as determining whether a particular patient has malignant or benign cancer or tumor based on the symptoms and the health records and history. It is also being used in future predictions where the patients are being told well in advance about their deteriorating health and the preventions which they should take to get back to a normal and healthy life.
- Artificial intelligence has been creating a virtual care private assistant which is specifically built for people's needs and is widely used for monitoring researching different types of cases and for analysis over the past cases and their outcomes. It also seeks to improve their models and assistant's efficiency by predicting what could be improved and thereby making themselves smarter.
- The use of healthcare bots is another efficient move taken by the medical industry to work their way up in the field of medicine which is known to provide 24/7 assistance and take up the less important work of managing appointments.

B. In the Field of Air Transport

- One of the major systematic transport in the world is air transport and there became an urgent need to optimize the way they are operated. Here came the involvement of artificial intelligence where the machine is involved in planning the routes, along with flight landing and take-off charts.
- The navigation maps and taxing routes, along with a quick check of the entire cockpit panel to ensure the correct working of every component has been performed with the use of artificial intelligence in many aircraft. This has been delivering very promising results and therefore is being adopted very frequently. The ultimate aim of artificial intelligence in the field of air transport is to give humans ease and a more comfortable journey.

C. In the field of Banking and Financial Institutions

- The artificial intelligence has been playing a significant role in managing financial transactions and also to handle numerous other activities in the bank. The day to day tasks of the banks such as transactional and financial operations, stock market money and their management, etc. are being worked upon by these machine learning models in a much more easier and efficient way.
- Use cases such as those of Anti-money laundering where the suspicious financial transactions are being monitored and are reported to the regulators is a classic example of the use of artificial intelligence in the field of banking and financial industry. Other use cases include those like credit systems analysis which are popular among credit card companies where the suspicious credit card transactions are tracked on the geographic level and based on various parameters is worked upon and resolved.

D. In the Field of Gaming and Entertainment

- From virtual reality games to the modern games which are there today, this is one industry where artificial intelligence has taken the biggest leap. The bots are always present to play with you and therefore you are not required to have a second person to play all the time.
- The level of personal details and the graphics are also possible due to the advent of artificial intelligence.

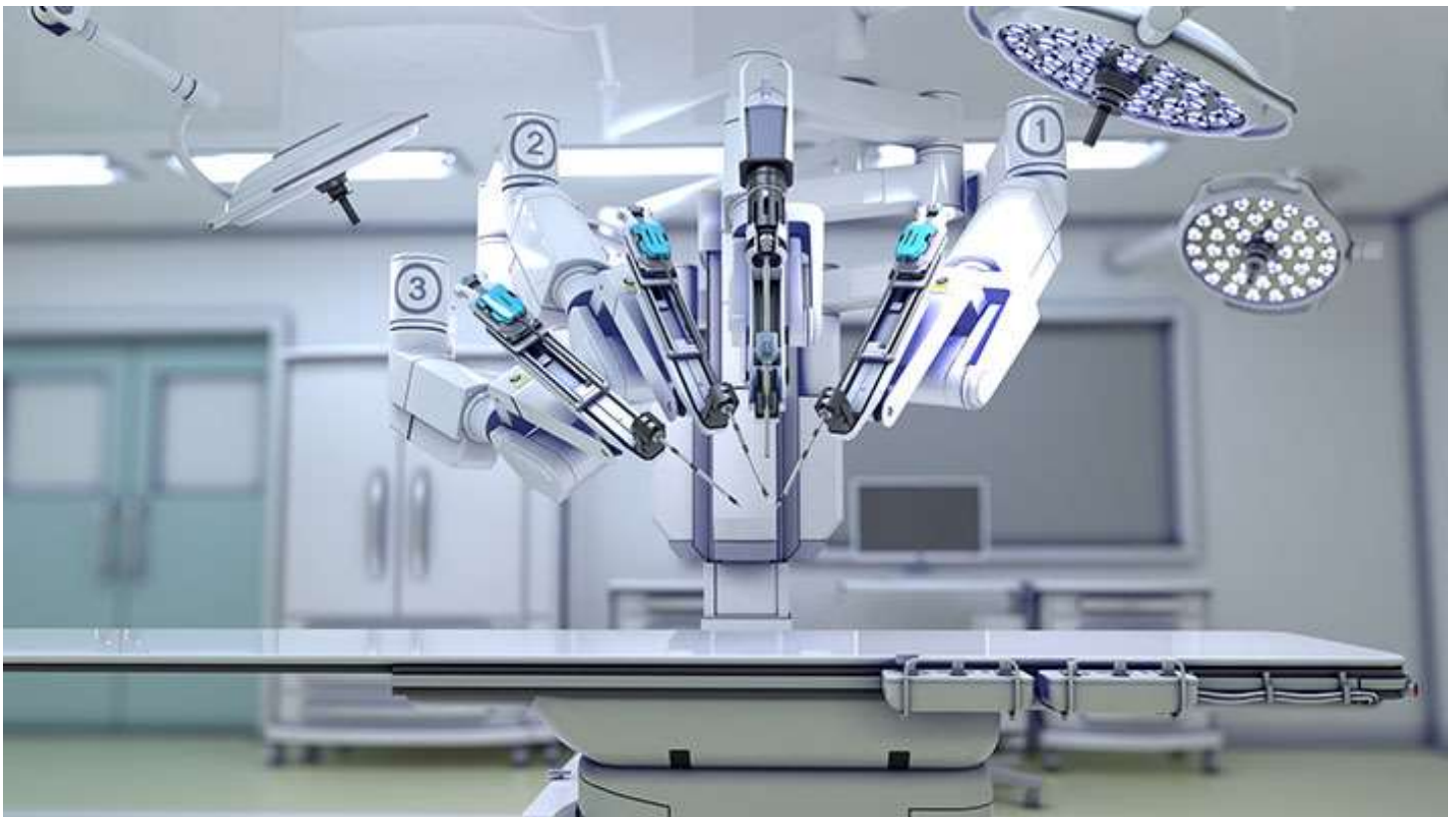
3. Applications of Artificial intelligence AI (Solving real life problems)

AI is relevant to any intellectual task. Modern artificial intelligence techniques are too numerous to list. Frequently, when a technique reaches mainstream use, it is no longer considered artificial intelligence; this phenomenon is described as the AI effect.

High-profile examples of AI include autonomous vehicles (such as drones and self-driving cars), medical diagnosis, creating art (such as poetry), proving mathematical theorems, playing games (such as Chess or Go), search engines (such as Google search), online assistants (such as Siri), image recognition in photographs, spam filtering, predicting flight delays, prediction of judicial decisions, targeting online advertisements, and energy storage.

With social media sites overtaking TV as a source for news for young people and news organizations increasingly reliant on social media platforms for generating distribution, major publishers now use artificial intelligence (AI) technology to post stories more effectively to generate higher volumes of traffic.

A. Healthcare



A patient-side surgical arm

AI in healthcare is often used for classification, whether to automate initial evaluation of a CT scan or EKG or to identify high-risk patients. The range of applications is rapidly increasing. As an example, In 2016, a groundbreaking study in California found that a mathematical formula developed with the help of AI correctly determined the accurate dose of immunosuppressant drugs to give to organ transplant patients.

Artificial intelligence is assisting doctors in Surgeries as well as Prescriptions and data management. According to Bloomberg Technology, Microsoft has developed AI to help doctors find the right treatments for cancer. There is a great amount of research and drugs developed relating to cancer. In detail, there are more than 800 medicines and vaccines to treat cancer. This negatively affects the doctors, because there are too many options to choose from, making it more difficult to choose the right drugs for the patients. Microsoft is working on a project to develop a machine called "Hanover". Its goal is to memorize all the papers necessary to cancer and help predict which combinations of drugs will be most effective for each patient.

B. Automotive

Advancements in AI have contributed to the growth of the automotive industry through the creation and evolution of self-driving vehicles. As of 2016, there are over 30 companies utilizing AI into the creation of self-driving cars. A few companies involved with AI include Tesla, Google, and Apple.

Many components contribute to the functioning of self-driving cars. These vehicles incorporate systems such as braking, lane changing, collision prevention, navigation and mapping. Together, these systems, as well as high-performance processing units, are integrated into one complex vehicle.

One main factor that influences the ability for a driverless automobile to function is mapping. In general, the vehicle would be pre-programmed with a map of the area being driven. This map would include data on the approximations of street light and curb heights in order for the vehicle to be aware of its surroundings. However, Google has been working on an algorithm with the purpose of eliminating the need for pre-programmed maps and instead, creating a device that would be able to adjust to a variety of new surroundings.

C. Finance and economics

Financial institutions have long used artificial neural network systems to detect charges or claims outside of the norm, flagging these for human investigation. The use of AI in banking can be traced back to 1987 when Security Pacific National Bank in the US set-up a Fraud Prevention Task force to counter the unauthorized use of debit cards.

Banks use artificial intelligence systems today to organize operations, maintain book-keeping, invest in stocks, and manage properties. AI can react to changes overnight or when business is not taking place. In August 2001, robots beat humans in a simulated financial trading competition. AI has also reduced fraud and financial crimes by monitoring behavioral patterns of users for any abnormal changes or anomalies.

D. Law-related professions

Artificial intelligence (AI) is becoming a mainstay component of law-related professions. In some circumstances, this analytics-crunching technology is using algorithms and machine learning to do work that was previously done by entry-level lawyers.

In Electronic Discovery (eDiscovery), the industry has been focused on machine learning (predictive coding/technology assisted review), which is a subset of AI. To add to the soup of applications, Natural Language Processing (NLP) and Automated Speech Recognition (ASR) are also in vogue in the industry.

E. Video games

In video games, artificial intelligence is routinely used to generate dynamic purposeful behavior in non-player characters. In addition, well-understood AI techniques are routinely used for pathfinding. Some researchers consider in non-player characters AI in games to be a "solved problem" for most production tasks.

F. Military

The United States and other nations are developing AI applications for a range of military functions. The main military applications of Artificial Intelligence and Machine Learning are to enhance Communications, Sensors, Integration and Interoperability. AI research is underway in the fields of intelligence collection and analysis, logistics, cyber operations, information operations, command and control, and in a variety of semiautonomous and autonomous vehicles. Artificial Intelligence technologies enable coordination of sensors and effectors, threat detection and identification, marking of enemy positions, target acquisition, coordination and de-confliction of distributed Joint Fires between networked combat vehicles and tanks also inside Manned and Unmanned Teams (MUM-T). AI has been incorporated into military operations in Iraq and Syria.

G. Hospitality



In the hospitality industry, Artificial Intelligence based solutions are used to reduce staff load and increase efficiency by cutting repetitive tasks frequency, trends analysis, guest interaction, and customer needs prediction. Hotel services backed by Artificial Intelligence are represented in the form of a chat-bot, application, virtual voice assistant and service robots.

H. Audit

For financial statements audit, AI makes continuous audit possible. AI tools could analyze many sets of different information immediately. The potential benefit would be the overall audit risk will be reduced, the level of assurance will be increased and the time duration of audit will be reduced.

I. Advertising

It is possible to use AI to predict or generalize the behavior of customers from their digital footprints in order to target them with personalized promotions or build customer personas automatically. A documented case reports that online gambling companies were using AI to improve customer targeting.

Nigeria's AI opportunities

Given these trends, Nigeria, Africa's most populated country, is in a great position to capitalize on the AI boom (4th industrial Revolution). Here are four ways AI could be actualized and make impacts here in our great country.

- **Virtual assistants:** The public sector fields thousands of questions a month from the general public, taking up valuable human resources and more importantly, time. AI-powered assistants can not only answer questions with higher speed and accuracy, but they can also learn, develop, and get smarter with each question.
- **Better predictions:** AI can use predictive algorithms to protect governments from corruption and financial fraud. Such technologies can also predict the seriousness of wounds and help medics prioritize treatment and evacuation. Predictive AI can even forecast weather more accurately.
- **Better health care services:** With a public health care system in Nigeria, the government could use AI to assist surgeons during necessary procedures. In some cases, AI-powered surgeons have outperformed their human counterparts. African hospitals have already started using AI for analyzing genomic data and there is no reason why Nigeria should not be one of the first African taking these bold steps in the evolution into a new age.
- **Criminal Identification:** AI could use facial recognition algorithms to identify criminals better. A study was conducted to conclude just that, and it was successful. Researchers trained their algorithm on 1856 different images of Chinese men, half of whom were known criminals. The algorithm was able to correctly spot the criminal and non-criminal 89.5 percent of the time.

The rise of Artificial Intelligence asks as many questions as it answers. Such a relevant technology is sure to revolutionize the way the world functions. Overall, these four points are just a few of the many reasons Nigeria should be optimistic about the future. AI will not only influence government but businesses as well. It is critical that these sectors cooperate. By keeping these points in mind, I'm confident that we Africans can use AI to build smart and efficient cities. (Ronald Chagoury- Business Day, May 2020)

QUIZ

1. Which of the options below does not form part of the branched of AI?
(a) Fuzzy Logic & Robotics (b) Machine Learning & Neural Networks (c) Forensics & Intelligence
(d) Natural Language processing & Expert Systems (e) none of the above
2. Allan Turing's test was carried out in which decade?
(a) 1940s (b) 1950s (c) 1960s (d) none of the above (e) 1930s
3. The field of artificial intelligence research was founded as an academic discipline in _____.
(a) 1945 (b) 1956 (c) 1965 (d) none of the above (e) 1966
4. What is the full meaning of AI? (a) Amplified Instructions (b) Artificial Instructions (c) Amplified Intelligence
(d) Artificial Intelligence (e) none of the above
5. Under Natural language processing, How many Languages can AI be made to understand and correctly interpret? (a) none of the above (b) Only English [1] (c) English and two others [3] (d) maximum of 7 languages (e) 5

UNDERSTANDING ROBOTICS AND AI – 1

Outline

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Definition of robots and robotics

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Terminologies in robotics

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Classification of robots

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Main components of a robot

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Quiz

1.1 Robots and Robotics

A **robot** is a machine, especially one programmable by a computer, capable of carrying out complex series of actions automatically. Robots can be **autonomous** or **semi-autonomous** and can be guided by an external control device or have their control embedded within.

The word robot was first used in a play written by a Czech writer; *Karel Capek* titled *Rossum's Universal Robots* in 1920 though it was Karel's brother *Josef Capek* who was the word's true inventor. It originates from the Slavic word, **robota** which means drudgery or hardwork in Czech and also work or labour in many Slavic languages (e.g: Bulgarian, Russian, Serbian, Slovak, Polish, Macedonian e.t.c.).

Therefore we can draw the conclusion that the word robot is used to describe any machine that has been designed to replace human labour in performing repetitive and dangerous tasks which humans prefer not to do, or are unable to do because of size limitations or which take place in extreme environments such as outer space or the bottom of the sea.

Some examples of world class popular robots include; Walker, Cruzr, Embot, ATRIS, Cheetah, Advanced Step in Innovative Mobility (ASIMO),

TOSY Ping Pong Playing robot (TOPIO), e.t.c.

Robotics on the other hand, is an interdisciplinary field that employs science, technology and engineering to design, construct, program and operate robots. It can further be described as a study that encompasses all aspects of robot design and implementation including computer systems for their control, sensory feedback and information processing.

The cheetah a military quadrupedal robot from Boston Dynamics set the record as the world's fastest robot in 2012

1.2 Terminologies in Robotics

Like every other professional discipline, robotics incorporates several terms and terminologies used to describe various aspects of robots ranging from hardware and software to performance characteristics. Acknowledging how numerous they are, for the sake of this course, we are going to treat some specialized words you will likely encounter in subsequent modules of this course.

We are also going to classify these terms in relation to what aspects of robots/ robotics to which they are peculiar. A quick reminder, as earlier stated, this is not an exhaustive list of terms but a summarized compilation of important keywords, used to describe robots and their functions.

1.2.1 Terms relating to form and appearance

1. Humanoid: A robot with its body shape built to take the physical form of a human body, not necessarily having all features. Generally humanoid robots have a torso, a head, two arms and two legs. Some humanoid robots only model part of the human body, for example from waist up.

Walker and cruzr Humanoid robots manufactured by UBTECH corporation

2. Android: A humanoid robot built to aesthetically resemble humans and is often made from a flesh like material. While the term android is generally used to describe human like robots, a robot designed to take a female appearance is called a **gynoid**.

3. Legged robot: Legged robots are a type of mobile robot which use articulated limbs, such as leg mechanisms, to provide locomotion. Legged

robots usually imitate legged animals, such as humans or insects. They are more versatile than **wheeled robots** and can traverse many different terrains.

1.2.2 Terms relating to robot movement

4. Axis/degrees of freedom: The number of axes or degrees of freedom describes how the robot arm or body can maneuver. A good indicator of the number of axes is the number of joints; the more joints, the more degrees of freedom. However, axes and joints are not always a 1:1 ratio; it depends on how each joint moves, and how the robot is designed.

Generally, a joint with 2 motors could provide 2 degrees of freedom.

The axes start with x, y, and z and then add the capability to tilt and turn.

Degrees of freedom is an extremely important consideration and capability (or limitation) to consider when selecting a robot for an application. While more axes/degrees of freedom give you more flexibility, it also makes the programming more complicated.

5. Reach: This term is used to describe the maximum limits of movement by a robot's manipulator. The more axes or degrees of freedom a robot has, the less linear the reach will be.

6. Hand guiding: Hand guiding is a feature commonly found in **collaborative robots** that allows the robot to be moved manually into different positions or waypoints to help teach the robot how to do a task. Hand guiding is usually used to program collaborative robots. A good example of hand guiding is the **Pose Record Play (PRP)** function of our robotics educational resources which you will encounter later in this course.

7. Servo motor: A servo motor is a rotary actuator or a motor that allows for a precise control in terms of the angular position, acceleration, and velocity. Basically it has certain capabilities that a regular motor does not have. Consequently, it makes use of a regular motor and pairs it with a sensor for position feedback. Although there exist many various kinds of electric motors, servomotors are the most commonly used in robotics,

because of their ability to precisely set positions and control other variables at the instructions of a microcontroller/ microprocessor.

1.2.3 Terms relating to robot programming

8.

Algorithm: An algorithm is a series of logical steps described to be followed by a computer program to solve a problem or perform a task. Algorithms are usually documented in form of **pseudo codes** and **flowcharts**. They are not computer programs in themselves but a helpful guide in dissecting a complex task into simple programmable elements. It is usually advisable to define an algorithm before setting out to writing a computer program as this will enable us understand the program flow better and act as a guide to optimization of our code for better efficiency.

9.

Programming language: A programming language is a defined standard of syntax and semantics that can be easily parsed by specific computer software in order to generate executable binary images which the computer can understand. The native language of all computers is **machine code**, which comprises of binary (1s and 0s) so arranged in a logical manner that give instructions to the **microcontroller/ microprocessor** to perform certain task(s) intended by the programmer. There are **high level programming languages** and **low level programming languages**. High level languages provide a great level of abstraction from a computer instruction set architecture and are close to human readable language. A big advantage of high level languages is what we refer to as **code portability** which is the ability to run the same program on various computers with various processors. The draw back to using high level languages is that they are relatively slower in execution compared to their low level counterparts and use more memory. Examples of high level languages include C, C++, Pascal, Java, python, ruby, perl e.t.c.

1.2.4 Terms relating to robot safety

10. Collaborative robot: Collaborative robots are robots that have been designed to work safely alongside human beings. Their operation is usually **force limited** to enable them work safely around humans without causing injury or incidents.

11. Force limiting: Force limiting is a safety feature that can allow robots to operate near humans without cages or other barriers. A force-limited robot will generally move at a slow, safe speed and will have sensors that detect impact and will stop movement if a threshold is crossed.

1.3 Main components of a robot

Control System

At the most basic level, human beings and other animals survive through a principle called feedback. Human beings sense what is going on around them and react accordingly.

A robot's control system uses feedback just as the human brain does. However, instead of a collection of neurons, a robot's brain consists of a silicon chip called a central processing unit, or CPU, that is similar to the chip that runs your computer. Our brains decide what to do and how to react to the world based on feedback from our five senses. A robot's CPU does the same thing based on data collected by devices called sensors.

Arduino Uno built upon ATMEGA328-PU microcontroller one of the most popular open source boards for robotics prototyping

Sensors

Robots receive feedback from sensors that mimic human senses such as video cameras or devices called light-dependent resistors that function like eyes or microphones that act as ears. Some robots even have touch, taste and smell. The robot's CPU interprets signals from these sensors and adjusts its actions accordingly. Some common examples of sensors used in robotics include; ultrasonic sensor, infra-red sensor, colour sensor, touch sensor, e.t.c.

Ultrasonic sensor

Actuators

To be considered a robot, a device must have a body that it can move in reaction to feedback from its sensors. Robot bodies consist of metal, plastic and similar materials. Inside these bodies are small motors called actuators. Actuators mimic the action of human muscle to move parts of the robot's body. The simplest robots consist of an arm with a tool attached for a particular task. More advanced robots may move around on wheels or treads. Humanoid robots have arms and legs that mimic human movement. The most commonly found motor in the robot's actuator is a **servo motor**.

Servo motor from UBTECH Jimu robot set

Power Supply

In order to function a robot must have power. Human beings get their energy from food. After we eat, the food is broken down and converted into energy by our cells. Most robots get their energy from electricity. Stationary robotic arms like the ones that work in car factories can be plugged in like any other appliance. Robots that move around are usually powered by batteries. Our robotic space probes and satellites are often designed to collect solar power.

End Effectors

In order to interact with the environment and carry out assigned tasks, robots are equipped with tools called end effectors. These vary according to the tasks the robot has been designed to carry out. For example, robotic factory workers have interchangeable tools such as paint sprayers or welding torches. Mobile robots such as the probes sent to other planets or bomb disposal robots often have universal grippers that mimic the function of the human hand.

Quiz

1. A machine programmable by a computer capable of carrying out complex series of actions automatically is called a _____
a. automatic machine b. robot c. embedded system
2. A robot built to aesthetically resemble humans is called an _____

a. arthropod **b.** humanoid **c.** android

3. _____ determines how a robot arm/ body can maneuver

a. Degrees of freedom **b.** reach **c.** Hand guiding

4. A feature of some robots that enables them to learn a particular task through positioning and repositioning is known as _____

a. adaptive learning **b.** hand guiding **c.** collaboration

5. Algorithms are not documented in one of these forms

a. flow charts **b.** pseudo codes **c.** comments

6. The major advantage of high level programming languages is

a. code portability **b.** memory efficiency **c.** better run time

7. _____ is not an example of a low level programming language

a. Assembly **b.** Machine code **c.** Python

8. _____ enables robots to work safely near humans

a. Force limiting **b.** Hand guiding **c.** Reach

9. The tool attached to an industrial robot for it to interact with the work piece is known as an _____

a. end tooling **b.** end effector **c.** power tool

10. The most commonly used type of motor in robotics is the _____

a. stepper motor **b.** servo motor **c.** brushless dc motor

