About Lesson

Based on Operation

Preprogrammed Robots

Pre- programmed robots operate in a controlled environment where they do simple and monotonous tasks. An example of a preprogrammed robot would be a mechanical arm on an automotive assembly line

Humanoid Robots

A humanoid robot is a robot with its body shape built to resemble the human body. The design may be for functional purposes, such as interacting with human tools and environments, for experimental purposes, such as the study of bipedal locomotion.

Some humanoid robots also have heads designed to replicate human facial features such as eyes and mouths.

Teleoperated Robots

Tele-operated robots are remotely controlled robots. they might have some sort of intelligence , but normally they take their command from a human operator and execute exactly as instructed. Right now, tele-operated robots are mostly used in medical surgeries and military operations.

device would be a prosthetic limp. or bionic arm

Autonomous Robots

An autonomous robot is a robot that is designed and engineered to deal with its environment on its own, and work for extended periods of time without human intervention. A truly autonomous robot is one that can perceive its environment, make decisions based on what it perceives and/or has been programmed to recognize conditions and then actuate a movement or manipulation within that environment.

About Lesson

Based on physical configuration

- Cartesian configuration
- Cylindrical configuration
- Polar configuration
- Joint-arm configuration

We will learn more about it in the upcoming lessons

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About Lesson

Evolution of Robotics

[illegible] by agencies outside of consumer manufacturing. The Case Western Reserve arm developed by Norman F. Diedrich was supported by the Space Nuclear Propulsion Office. A similar design, the "Programmable Universal Manipulator for Assembly" (PUMA) developed in the 1960s by Victor Sheinman, a graduate student at Stanford University, was intended for microsurgery. PUMA was eventually licensed and improved by the Unimation Corporation in 1978. Taking advantage of advances in other technologies, developers gradually integrated more sophisticated computer controls and precision components into their models. Higher degrees of freedom—how far a component could move away from "home" position—led to greater versatility. The addition of finger joints in some models created manual dexterity for grasping, holding, and positioning objects. In 1960 a General Electric research team headed by Ralph Mosher developed "Handyman" and "Man-Mate"—two remotely operated robotic arms. Handyman, a two-arm electro-hydraulic teleoperated robot, had two hinge-type jointed fingers that could grasp objects via a single command from the human operator wearing the Handyman apparatus. Other robotic "arms" were actually based on the human spine. The multiple joints in these "serpentine" arms allowed for flexibility required in product-inspection operations. A different kind of robotic arm configuration was used in NASA's Viking mission to Mars during 1975-76. The Viking landers, designed by the Martin Marietta Corporation, had to be designed with the extreme environmental conditions of Mars in mind. Instead of the heavy, jointed industrial arm, the Viking arms were made of two light, ribbon-like extenders rolled onto a drum. The two halves unfurled and connected, creating a tube to scoop samples from the planet's surface. Although the arm control mechanism had some bugs in it, operators on Earth were able to guide the robot through a repair procedure, making researchers optimistic about aerospace telerobotics—human control of robots from a remote location. The desire to have machines that could follow commands or operate by themselves through many complex operations required special programming and controls for the machines. Some researchers came to believe that the best way to control what machines did for people was to find some artificial means to simulate the way that humans thought, remembered, and responded to their environments. Thus the study of artificial intelligence (AI) grew up alongside robotics engineering. The term "Cybernetics"—the study of the relationship between human and machine intelligence—was coined by scientist Norbert Wiener (1894-1964) in the 1940s, while he and a colleague, Dr. Arturo Rosenbluth, were working on ways to improve the automatic controllers in military aircraft. Since that time researchers have been experimenting with computer simulations of human thought. Although researchers disagreed about how the human brain works, the AI projects that arose from their debate have become a significant factor in the development of robots. Another trend in robotics was to create mobile robots that could operate independently of humans. In order to do this, the robot must be able to avoid stationary and moving objects in its path. "Shakey," a primitive version of a mobile service robot based on this idea, was built at the Stanford Research Center in 1968. It had a vision sensor (a motorized camera and range-finder) positioned above a central processing unit (computer) on a cart. Shakey was propelled by two motorized wheels and two obstacle-sensing bumpers. It could apply logic-based methods of problem solving that allowed it to recognize the shape of objects, push them, and negotiate a ramp. Like Shakey, service robots of the 1980s were essentially "brains in a box" that ran along pre-mapped pathways laid out on the floor and could recognize and maneuver around obstacles. More recent models, like the RoboKent(r) SweeperVacs and Recycling ScrubberVacs from the Servus Robots Company, learn the area to be cleaned by themselves. They operate independently, without reference targets, and have builtin obstacle detection and avoidance protocols. Robots have cleaned more than offices: they have been used for larger, environmental hazard jobs, such as the cleanup at the Chernobyl nuclear power plant in the Soviet Union, following a major radioactive explosion there in 1986. Shakey's ability to learn from interaction of its sensors with the environment also became the basis for the small, insect-like robots developed by researchers such as Rodney Brooks of the Massachusetts Institute of Technology (MIT) beginning in the 1980s. Brooks believed that the interaction of machine sensors with their environment creates a learning situation for robots similar to that of a human infant. According to this theory, it is not necessary to build complex computers with thousands of stored facts to control the robot. Instead, simple motor and sensor elements are combined to create robots that learn from experience. Brooks built robots modeled on multi-legged insects such as "Genghis"—designed to negotiate the kind of rough terrain that would be encountered on other planets. NASA planned to utilize "Hermes," a smaller version of Genghis, to explore the surface of Mars. Many researchers argue that a humanoid robot is best for adapting to the human environment. When Rodney Brooks and Andrea Stein co-founded the COG humanoid robot project at MIT, their goal of producing an android that could behave like a human being and interact with human beings was considered controversial. Soon, other similar projects were in development. Vanderbilt University School of Engineering has been working on a humanoid robot called "ISAC." ISAC, like COG, is learning to interact with human people in a natural way. The projected use for ISAC is to perform as an in-home care-giver. Other university-based robotics research in the United States, including projects at the University of Southern California, the University of California-Berkeley, and Georgia Tech are destined for use in medical, private and military security capacities, or in environmental hazard situations. U.S. and European robotics research is tackling issues such as mobility, robot-human interaction, vision systems, speech imitation and recognition, and cognition. These topics are nothing new to Japanese robot designers. Japan, which has almost twice as many robots as the United States, is developing android type robots for wide-ranging uses—to work outside of space stations and spacecraft, to interact with its growing geriatric population in hospitals and at home, and to act as civil servants in urban centers. By 1986 the Honda Motor Company had completed "P-1," meant to "coexist and cooperate with human beings." Honda expected that by the time their humanoid robot was perfected, such robots would be used in everyday life to serve humans, not just in special operations. In the fall of 1997 Honda completed "P-3," which looks like a suited astronaut. It has a backpack with a 136-volt battery, wireless receiver, and processing unit. Commands are transmitted by the wireless ethernet modem. According to Honda, P-3's vision sensing system is able to identify stairs and other objects in a room, walk up stairs, and restabilize itself when pushed off balance. At Waseda University, Japan, researchers have been working with another android project, "Hadaly." Like MIT's COG, Hadaly still looks much like a Leggo project with cameras for eyes, but researchers in other labs are working hard at simulating a human brain to someday operate inside of androids like Hadaly. Meanwhile, Fumio Hara and a team of researchers at the Science University in Tokyo have been working on an industrial "face robot" that can identify dozens of human expressions and make facial gestures itself. Recently, the face robot has been fitted with a simulated skin, hair, and eyes. Its designers believe that worker interaction with a humanoid face that provides emotional as well as verbal response will help reduce industrial accidents.

Robotics is now one of humanity's greatest achievements and the single greatest endeavour to create an artificial, sentient entity. The idea of a machine that looks and behaves like a human being goes back at least 2,000 years. According to Greek mythology, Hephaestus, the god of fire, constructed artificial women out of gold. These women were able to walk, talk, and even to think.

The name "robot" was originated from the Czechoslovakian word for "forced labour," which was used in 1921 in a play by Karel Capek's called R.U.R. ("Rossum's Universal Robots") to portray an army of manufactured industrial slaves. Since then, we've come to think of robots as modern science fiction's mechanical men or "androids."

~77-100BC

In 1901, between the islands of Crete and Kythera, a diver found the remnants of what might only be considered a mechanical computer. The device is a complex mix of gears which most likely calculated the position of the sun, moon or other celestial bodies. The device dates back 2000 years and is considered to be of Greek origin and was given the name "The Antikythera Device".

278 – 212BC

Archimedes (287-212BC) did not invent robots, but he did invent many mechanical systems that are used in robotics today, as well as advancing the field of mathematics.

10-70AD

The Hero of Alexandria, a Mathematician, Physicist and Engineer (10-70AD) wrote a book titled Automata (Arabic translation, or in Greek "moving itself") which is a collection of different devices which could have been used in temples. The Hero of Alexandria designed an odometer to be mounted on a cart and measure distances traveled. Among his other inventions are a wind- powered organ, animated statues and the Aeolipile. Although conceived simply as a trinket, the Aeolipile can be considered the forefather of modern steam engines

Medieval times

Automatons, human-like figures run by hidden mechanisms, were used to impress peasant worshippers in church into believing in a higher power. [These mechanisms] created the illusion of self-motion (moving without assistance). The clock jack was a mechanical figure that could strike time on a bell with its axe. This technology was virtually unheard of in the 13th century

1495

Leonardo da Vinci designed what may be the first humanoid robot though it cannot be confirmed if the design was actually ever produced. The robot was designed to sit up, wave its arms, and move its head via a flexible neck while opening and closing its jaw.

1645

Blaise Pascal invented a calculating machine to help his father with taxes. The device was called the Pascaline and about 50 Pascalines were built. Only a few can be found in museums such as the one on display in the Des Arts et Metiers Museum in Paris.

1666

A pocket version of the Pascaline was invented by Samuel Morland which worked "without charging the memory, disturbing the mind, or exposing the operations to any uncertainty"

18th Century

In the 18th century, miniature automatons became popular as toys for the very rich. They were made to look and move like humans or small animals.

1709

Jacques de Vaucanson's most famous creation was undoubtedly "The Duck." This mechanical device could flap its wings, eat, and digest grain. Each wing contained over four hundred moving parts and even today it remains something of a mystery. The original Duck has disappeared.

1801

Joseph-Marie Jacquard invented a machine (essentially a loom) that could be programmed to create designs that could be printed onto cloth or tissue.

1865

John Brainerd created the Steam Man apparently used to pull wheeled carts and more. In 1885, Frank Reade Jr. built the "Electric Man" which is more- or-less an electric version of the Steam Man.

1903

The first patents were awarded for the construction of a "printed wire" which came into use after World War 2. The concept was to replace radio tube with something less bulky.

1921

The term "robot" was first used in a play called "R.U.R." or "Rossum's Universal Robots" by the Czech writer Karel Capek. The plot was simple: man creates a robot to replace him and then robot kills man!

1937-1938

Westinghouse creates ELEKTRO a human-like robot that could walk, talk, and smoke. ELEKTRO was first unveiled at the 1939 world's fair.

1941

Science fiction writer Isaac Asimov first used the word "robotics" to describe the technology of robots and predicted the rise of a powerful robot industry.

The term robotics refers to the study and use of robots; it came about in 1941 and was first adopted by Isaac Asimov, a scientist and writer. It was Asimov who also proposed the following "Laws of Robotics" in his short story Runaround in 1942.

1942

Isaac Asimov wrote the "Three Laws of Robotics". A zeroth law was later added (law zero below).

Law One: A robot may not injure a human (or humanity), or, through inaction, allow a human (or humanity) to come to harm.
Law Two: A robot must obey orders given it by human beings, except where such orders would conflict with a higher order law.
Law Three: A robot must protect its own existence as long as such protection does not conflict with a higher order law]

Law Zero: A robot may not injure a human being, or, through inaction, allow a human being to come to harm, unless this would violate a higher order law

1942

The first "programmable" mechanism, a paint-sprayer, was designed by Willard Pollard and Harold Roselund for the DeVilbiss Company. (US Patent No. 2,286,571).

1946

George Devol patented a general purpose playback device for controlling machines using magnetic recordings.

1947

On November 14, 1947, Walter Brattain had an accident while trying to study how electrons acted on the surface of a semiconductor. This accident brought about the creation of the first transistor.

1948

W. Grey Walter created his first robots; Elmer and Elsie, also known as the turtle robots. The robots were capable of finding their charging station when their battery power ran low.

1951

Raymond Goertz designed the first tele-operated articulated arm for the Atomic Energy Commission. This is generally regarded as a major milestone in force feedback (haptic) technology. (US Patent 2679940)

1954

George Devol designed the first truly programmable robot and called it UNIMATE for "Universal Automation." (US patent 2 998 237). Later, in 1956, George Devol and Joseph Engelberger formed the world's first robot company "Unimation" which stands for "universal automation". As a result, Engelberger has been called the 'father of robotics'. Unimation is still in production today, with robots for sale.

1957

History changed on October 4, 1957, when the Soviet Union successfully launched Sputnik I. The world's first autonomous, artificial satellite was 22.8 inches in diameter and weighed only 183.9 pounds.

1960's

One of the first operational, industrial robots in North America appeared in the early 1960's in a candy factory in Kitchener, Ontario.

1964

Artificial intelligence research laboratories are opened at M.I.T., Stanford Research Institute (SRI), Stanford University, and the University of Edinburgh.

1965

Carnegie Mellon establishes the Robotics Institute.

1968

The first computer controlled walking machine was created by Mcgee and Frank at the University of South Carolina.

1968

The first manually controlled walking truck was made by R. Mosher. It could walk up to four miles an hour

1968

SRI built "Shakey"; a mobile robot equipped with a vision system and controlled by a computer the size of a room.

1969

Victor Scheinman created the Stanford Arm, which was the first successful electrically-powered, computer-controlled robot arm.

1969

WAP-1 became the first biped robot and was designed by Ichiro Kato. Air bags connected to the frame were used to stimulate artificial muscles. WAP-3 was designed later and could walk on flat surfaces as well as climb up and down stairs or slopes. It could also turn while walking.

1973

V.S. Gurfinkel, A. Shneider, E.V. Gurfinkel and colleagues at the department of motion control at the Russian Academy of Science create the first six-legged walking vehicle

1973

Ichiro Kato created WABOT I which was the first full-scale anthropomorphic robot in the world. It had a system for controlling limbs, vision, and conversation! It was estimated that it had the mental ability of a 18 month old child.

1973

Cincinnati Milacron released the T3, the first commercially available minicomputer-controlled industrial robot (designed by Richard Hohn).

1974

Intel (Integrated Electronics) produced the first batch of second-generation 8080 general purpose chips.

1975

Victor Schenman developed the Programmable Universal Manipulation Arm (Puma). It was widely used in industrial operations.

1975

The MITS ALTAIR was the first 8080 chip based kit computer and is arguably the start of the personal computer.

1977

The Variante Masha, a six-legged walking machine, was created at the Russian academy of Science by Dr. Devjanin, Dr. Grufinkelt, Dr. Lensky, Dr. Schneider, and colleagues.

1978

Shigeo Hirose created ACMVI (Oblix) robot. It had snake-like abilities. The Oblix eventually became the MOGURA robot arm used in industry.

1979

The Stanford Cart crossed a chair-filled room without human assistance. The cart had a TV camera mounted on a rail which took pictures from multiple angles and relayed them to a computer. The computer analyzed the distance between the cart and the obstacles.

1979

Hiroshi Makino of Yamanashi University designed the Selective Compliant Articulated Robot Arm (SCARA) for assembly jobs in factories.

1980

Quasi-dynamic walking was first realized by WL-9DR. It used a micro- computer as the controller. It could take one step every 10 seconds. It was developed by Ichiro Kato at the Department of Mechanical Engineering School of Science and Engineering, Waseda University, Tokyo.

1981

Shigeo Hirose developed Titan II. It is a quadruped which could climb stairs. Picture is of Titan III, which is a successor to Titan II.

1985

Created by the General Robotics Corp. the RB5X was a programmable robot equipped with infrared sensors, remote audio/video transmission, bump sensors, and a voice synthesizer. It had software that could enable it to learn about its environment.

1985

Waseda Hitachi Leg-11 (WHL-11) was a biped robot developed by Hitachi Ltd. It was capable of static walking on a flat surface. It was able to turn and could take a step every 13 seconds.

1985

A four legged walking machine, Collie1, was developed by H. Miura at the University of Tokyo. The machine had 3 degrees of freedom per leg.

1985

The Melwalk3 was developed at Namiki Tsukuba Science City and was a six- legged walking machine.

1988

The first HelpMate service robot went to work at Danbury Hospital in Connecticut.

1989

Aquarobot, a walking robot for undersea use, was created at the Robotics Laboratory at the Ministry of Transport in Japan.

1989

Developed by Kato Corporation, the WL12RIII was the first biped walking robot which was able to walk on a terrain stabilized by trunk motion. It could walk up and down stairs and could take a single step every 0.64 seconds.

1990

iRobot Corporation was founded by Rodney Brooks, Colin Angle and Helen Greiner and produced domestic and military robots.

1993

Dante explored Mt. Erebrus in Antarctica. The 8-legged walking robot was developed at Carnegie-Mellon University. However, the mission failed when its tether broke. Dante II subsequently explored Mt. Spurr in Alaska in 2004. This was a more robust version of Dante I.

1996

RoboTuna was created by David Barrett at MIT. The robot was used to study how fish swim.

1996

Honda created the P2, which was the first major step in creating their ASIMO. The P2 was the first self-regulating, bipedal humanoid robot.

1997

NASA's PathFinder landed on Mars. The wheeled robotic rover sent images and data about Mars back to Earth.

1997

IBM's deep blue supercomputer beat the champion Gary Kasparov at a chess match. This represented the first time a machine beat a grand champion chess player.

1997

Honda created the P3, the second major step in creating their ASIMO. The P3 was Honda's first completely autonomous humanoid robot.

1998

Dr. Cynthia created Kismet, a robotic creature that interacted emotionally with people.

1998

LEGO released their MINDSTORMS robotic development product line, which is a system for inventing robots using a modular design and LEGO plastic bricks.

1998

Campbell Aird was fitted with the first bionic arm called the Edinburg Modular Arm System (EMAS).

1999

Sony released the first Aibo robotic dog.

1999

Mitsubishi created a robot fish. The intention was to create a robotic version of an extinct species of fish.

1999

Personal Robots released the Cye robot. It performed a variety of household chores, such as delivering mail, carrying dishes, and vacuuming. It was created by Probotics Inc.

2000

Sony unveiled the Sony Dream Robots (SDR) at Robodex. SDR was able to recognize 10 different faces, expresses emotion through speech and body language, and can walk on flat as well as irregular surfaces. Image of QRIO

2001

iRobot Packbots searched through the rubble of the world Trade Center. Subsequent versions of the Packbot robots are used in Afghanistan and Iraq.

2001

MD Robotics of Canada built the Space Station Remote Manipulator System (SSRMS). It was successfully launched and worked to assemble the International Space Station.

2002

Honda created the Advanced Step in Innovative Mobility (ASIMO). It is intended to be a personal assistant. It recognizes its owner's face, voice, and name. Can read email and is capable of streaming video from its camera to a PC.

2002

iRobot released the first generation of Roomba robotic vacuum cleaners.

2003

As part of their mission to explore Mars, NASA launched twin robotic rovers on June 10 and July 7, 2003 called Spirit and Sojourner.

2003

RobotShop Distribution Inc. was founded to provide today's society with domestic and professional robot technology that can help increase the pleasure, knowledge liberty and security of individuals.

2005

The Korean Institute of Science and Technology (KIST), created HUBO, and claims it is the smartest mobile robot in the world. This robot is linked to a computer via a high-speed wireless connection; the computer does all of the thinking for the robot.

2005

Cornell University created self-replicating robots.

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About Lesson

Introduction to Robotics

Welcome to robotics! We're glad you found us.

Technology has changed our lives in countless ways, but it can also change them for the better. Robotics technology is expected to be one of the 21st century's greatest disruptors, helping us work more efficiently and even survive on other planets. Robotics is a field of science working with machines that perform tasks based on predetermined and adaptive programs and algorithms in an automatic or semi-automatic way. These machines – commonly called robots – are either controlled by humans or work entirely under the supervision of a computer application and algorithms. Robotics is a comprehensive concept that includes the building, planning and programming of robots. These robots are in direct contact with the physical world – and they have often been used to perform monotonous and repetitive tasks instead of human beings. Robotics technology has grown exponentially, making it possible for us to develop some amazing applications. From driverless cars to medical robots that can perform surgery and even detect skin cancer, these are just a few of the ways robotics is changing the world.

Robotics is the intersection of science, engineering and technology that produces machines called robots that substitute or replicate human actions

Since the beginning of time, people have wanted to build machines that could do things with technology.

Robotics is the study and development of the theory, design, construction, operation and application of autonomous agents that can perceive their environment and react to it.

Robotics involves understanding how a system works, such as its components or how it interacts with other systems. These include sensors that measure environmental conditions and computing systems that process information from those sensors.

Robotics is an important part of modern industry as it has been widely used in manufacturing processes. Robotics helps produce goods faster and more efficiently than human workers. In addition to this, robots have been used in many fields such as military technology, social sciences and even entertainment.

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Course Content

About Lesson

Characteristics of SCARA Robots

Some SCARA characteristics like high reliability, high accuracy and speed, minimum maintenance, ease of use and extremely compact design make this kind of robot really suitable to work; the composed system guarantees high performances in term of productivity and, at the same time, high flexibility in assembly lines and production systems. Also it does not require any retooling cost for product changeovers: product changes can be made in a matter of seconds without any trouble.

Advantages of SCARA robots

- Generally, a SCARA robot can operate at a higher speed and with optionals like cleanroom specifications.
- The SCARA robot is commonly used for pick-and-place or assembly operations when high speed and high accuracy are required.
- SCARA Robots currently available can achieve tolerances lower than 10 microns. This tolerances can be compared to 20 microns for a six-axis robot.
- The compact layout of SCARA Robots also makes them more easily re-located in temporary or remote applications: by design, the SCARA robot suits applications with a smaller field of operation and where floor space is limited.

lighter payload. Typically, they carry up to 2 kg nominal (10 kg maximum).

- The envelope of a SCARA robot is typically circular, which doesn't suit all applications, and the robot has limited dexterity and flexibility compared to the full 3D capability of other types of robots (e.g. six-axis robots).

About Lesson

The SCARA acronym stands for Selective Compliance Assembly Robot Arm or Selective Compliance Articulated Robot Arm.

The robot was developed under the guidance of Hiroshi Makino, a professor at the University of Yamanashi. The arms of SCARA are flexible in the XY-axes and rigid in the Z-axis that makes it to familiarize to holes in the XY-axes.

Scara is a type of Industrial robot.

The SCARA robot is most commonly used for pick-and-place or assembly operations where high speed and high accuracy is required. Generally a SCARA robot can operate at higher speed and with optional cleanroom specification.

Industrial robots are defined as 'multi-functional manipulators designed to move parts through various programmed motions'. As such, robots provides **consistent reliable performance, repetitive accuracy** and are able to handle heavy work loads and perform in harsh environments. Additionally, robots can be **quickly reprogrammed** to reflect changes in production needs and cycles.

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About Lesson

Applications for Cartesian Robots

The versatility, lower cost, and ease of programming make Cartesian robots viable for many applications in industrial settings. Let us have a look at some of them.

- **Pick and place:** The robotic arm is fitted with some variation of vision device to identify different components from a carousel or conveyor belt. The arm can pick these objects and sort them into different bins. Picking and soring can be done by a single robotic arm.
- **Process-to-process transfer:** In a production line there will be instances where goods in the process need to be transferred from one location to another. It can be done using dual-drive linear robots. They can be used with vision systems or time-synchronization depending on the rest of the process.
- **Assembling system:** When the same steps have to be repeated over and over to assemble the parts of a product, linear robots can be used to automate the tasks.
- **Application of adhesives and sealants:** Many production processes involve the application of adhesives or sealants between parts. It is used in large automobile manufacturing to small electronic gadget production. Adhesives and sealants are to be
- **Palletizing and depalletizing:** Packing uses pallets to transport goods with ease. Cartesian robots can be used to automate both placing products on pallets and taking them from pallets.
- **CNC machine tooling:** Computer numeric controls-based machines are used to create products according to designs made in engineering design software. CNC machines widely use linear robots with different tools attached to the robotic arms.
- **Precision spot welding:** Specialized welding is required in certain manufacturing processes. Linear robots with welding arms can achieve accurate welds in precise locations on the work surface. The high level of tolerance in the micrometers (μm) range is helpful in such applications.

About Lesson

Characteristics and Advantages

Cartesian robots have a higher payload carrying capacity compared to their equivalent six-axis robots. This, combined with the lower cost and ease of programming for linear robots, makes them suitable for a large variety of industrial applications. Gantry robots, which are essentially Cartesian robots with supporting scaffolding, can carry even higher payloads. The range of movement for linear robots can be extended by adding compatible modules to the existing mechanism. This modularity in Cartesian robots makes them much more versatile and has a longer life in an industrial setting.

Cartesian robots also exhibit a high level of accuracy and precision compared to their rotary counterparts. This is due to the fact that they only have linear motion and no need to accommodate rotary motion. Cartesian robots can have tolerances in the range of micrometers (µm), whereas six-axis robots generally have tolerances in the range of millimeters (mm).

About Lesson

How Do Cartesian Robots Function

Cartesian robots only move through linear motion, generally through servomotor drives. The linear actuators used can be in various forms according to the specific application. The drive system can be belt-driven, cable-driven, screw-driven, pneumatic-driven, rack-and-pinion-driven, or linear-motor-driven. Some manufacturers provide completely pre-made Cartesian robots that can be implemented without any modifications. Other manufacturers offer different components as modules, allowing the user to implement a combination of these modules according to their specific use case.

The robotic arms themselves can be equipped with "vision" or can be "blind" in operations. They can be attached to light sensors or cameras to identify the objects before executing an action. For example, Cartesian robots can be used in laboratories to pick and move samples. Computer-aided vision can be used to recognize the test tube, pipettes, or slides and the arm can grab the object according to the position data conveyed from the camera.

The advantage of Cartesian robots over other robotic systems, like six-axis robots, is that they are very easy to program. A single motion controller can handle the movement logic for a Cartesian robot. The robots have only linear motion, enabling ease of control. There is

About Lesson

Cartesian Robots

Mechatronic robots that use linear axes for movement are called Cartesian robots, linear robots, or gantry robots. Gantry robots look similar to gantry cranes and operate similarly. But gantry robots are not limited to lifting and moving functions. They can have custom functionality as per the requirement.

Cartesian robots have an overhead structure that controls the motion in the horizontal plane and a robotic arm that actuates motion vertically. They can be designed to move in x-y axes or x-y-z axes. The robotic arm is placed on the scaffolding and can be moved in the horizontal plane. The robotic arm has an effector or machine tool attached to the end of the arm depending on the function where it is used.

Though Cartesian robots and gantry robots are used interchangeably, gantry robots generally have two x-axes while Cartesian robots will have only one each of the two/three axes (according to the configuration).

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About Lesson

Cartesian System

Cartesian coordinate geometry is an excellent method for mapping three-dimensional space in a simple, easy-to-understand numerical system. In the Cartesian system for three-dimensional space, there are three coordinate axes that are perpendicular to each other (orthogonal axes) and meet at the origin.

The three axes are generally referred to as the x-axis, y-axis, and z-axis. Any point in three-dimensional space is represented by three numbers as (x, y, z). X represents the distance of the point from the origin along the x-axis, y is the distance from the origin along the y-axis, and z is the distance from the origin along the z-axis.

About Lesson

Applications

- Parallel robots are used in various industrial applications such as:
- Flight simulators
- Automobile simulators
- In work processes
- Photonics / optical fiber alignment

They are used in limit in the workspaces. To perform a desired manipulation, it would be very difficult and can lead to multiple solutions. Two examples of popular parallel robots are the Stewart platform and the Delta robot.

Advantages

- Very high speed
- Contact lens shaped working envelope
- Excels in high speed, lightweight pick and place applications (candy packaging)

Disadvantages

It requires dedicated robot controller in addition to line master controller like PLC/PCs

About Lesson

Parallel Configuration

Parallel robots are also known as parallel manipulators or generalized Stewart platforms.

A parallel robot is a mechanical system that uses several computer-controlled serial chains to support a single platform, or end-effector.

Furthermore, a parallel robot can be formed from six linear actuators that maintain a movable base for devices such as flight simulators. These robots prevent redundant movements and to carry out this mechanism, their chain is designed to be short, simple.

They are known as:
• High speed and high precision milling machines
• Micro manipulators mounted on the end effector of larger but slower serial manipulators

About Lesson

Applications:

Articulated robots can be used in Robots palletizing food (Bakery), Manufacturing of steel bridges, cutting steel, Flat-glass handling, heavy duty robot with 500 kg payload, Automation in foundry industry, heat resistant robot, metal casting, and Spot Welding.

Advantages

- High speed
- Large working envelope
- Great in unique controller, welding and painting applications

Disadvantage:

Typically requires dedicated robot controller in addition to line master controller like PLC/PC

About Lesson

Articulated Robot

An Articulated robot can be defined as a robot with rotary joint and these robots can range from simple two-jointed structures to systems with 10 or more interacting joints.

These robots can reach any point as they work in three dimensional spaces. On the other hand, articulated robot joints can be parallel or orthogonal to each other with some pairs of joints parallel and others orthogonal to each other. As articulated robots have three revolute joints, the structure of these robots is very similar to the human arm.

About Lesson

Cylindrical Robots

The base of cylindrical robots has a rotary joint, and the links are connected by prismatic joints. The robots have a cylindrical-shaped work envelop, which is achieved with rotating shaft and an extendable arm that moves in a vertical and sliding motion. Because of their compact design, cylindrical robots are frequently used in small spaces for simple assembly, machine tending, or coating applications.

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About Lesson

Cylindrical Coordinate System

A cylindrical coordinate system is a **three-dimensional coordinate system** that specifies point positions by the distance from a chosen reference axis, the direction from the axis relative to a chosen reference direction, and the distance from a chosen reference plane perpendicular to the axis. The latter distance is given as a positive or negative number depending on which side of the reference plane faces the point.

The origin of the system is the point where all three coordinates can be given as zero. This is the intersection between the reference plane and the axis.

The axis is variously called the cylindrical or longitudinal axis, to differentiate it from the polar axis, which is the ray that lies in the reference plane, starting at the origin and pointing in the reference direction.

T**he distance from the axis may be called the radial distance or radius**, while the angular coordinate is sometimes referred to as the **angular position or as the azimuth**. The radius and the azimuth are together called the polar coordinates, as they correspond to a two-dimensional polar coordinate system in the plane through the point, parallel to the reference plane. The third coordinate may be called the height or altitude (if the reference plane is considered horizontal), longitudinal position,or axial position.

Cylindrical coordinates are useful in connection with objects and phenomena that have

It is sometimes called "**cylindrical polar coordinate**"and "**polar cylindrical coordinate**", and is sometimes used to specify the position of stars in a galaxy ("galactocentric cylindrical polar coordinate").

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About Lesson

Polar / Spherical Coordinate Robots

Polar Robots, or spherical robots, have an arm with two rotary joints and one linear joint connected to a base with a twisting joint. The axes of the robot work together to form a polar coordinate, which allows the robot to have a spherical work envelope. Polar Robots are credited as one of the first types of industrial robots to ever be developed. Polar robots are commonly used for die casting, injection molding, welding, and material handling.

In other words, **spherical robot** is a robot with two rotary joints and one prismatic joint; in other words, two rotary axes and one linear axis. Spherical robots have an arm which forms a spherical coordinate system.

About Lesson

Spherical Coordinate System

In mathematics, **a spherical coordinate system** is a coordinate system for **three-dimensional space** where the position of a point is specified by three numbers: the radial distance of that point from a fixed origin, its polar angle measured from a fixed zenith direction, and the azimuth angle of its orthogonal projection on a reference plane that passes through the origin and is orthogonal to the zenith, measured from a fixed reference direction on that plane.

The radial distance is also called the radius or **radial coordinate**. The polar angle may be called colatitude, zenith angle, normal angle, or inclination angle.

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About Lesson

Important Terms

Positional Commands: A robot can perform the required position using a GUI or text based commands in which the essential X-Y-Z position may be specified and edited.

Teach Pendant: Using a teach pendant method, we can teach the positions to a robot. Teach pendent is a handheld control and programming unit that contain the capability to manually send the robot to a desired position. A teach pendant can be disconnected after the completion of programming. But, the robot runs the program, which was fixed in controller.

Lead-by-the-nose: Lead-by-the-nose is a technique which will be included by many robot manufacturers. In this method, one user holds the robot's manipulator, while another person enters a command that helps to de-energize the robot which will make it to go into limp.

Then, user can move the robot to the required position (by hand) while the software records these positions into memory. Several robot manufacturers use this technique for performing paint spraying.

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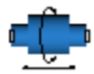
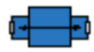
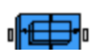
Name of joint	Representati on	Description
Revolute		Allows relative rotation about one axis.
Cylindrical		Allows relative rotation and translation about one axis.
Prismatic		Allows relative translation about one axis.
Spherical		Allows three degrees of rotational freedom about the center of the joint. Also known as a ball-and-socket joint.
Planar		Allows relative translation on a plane and relative

About Lesson

Joints allow restricted relative motion between two links

About Lesson

Links and Joints

The individual bodies that make up a robot are called 'links.' Here, unless otherwise stated, all links are assumed to be rigid, i.e., the distance between any two points within the body does not change while it is moving. A rigid body in the three dimensional Cartesian space has six DOF. This implies that the position of the body can be described by three translational, and the orientation by three rotational coordinates. For convenience, certain non-rigid bodies, such as chains, cables, or belts, which when serve the same function as the rigid bodies, may be considered as links. From the kinamatic point of view, two or more members when connected together without any relative motion between them is considered as a single link. For example, an assembly of two gears connected by a common shaft is treated as one link. Links of a robot are coupled by kinematic pairs or joints. A 'joint' couples two links and provides physical constraints on the relative motion between the links. It is not a physical entity but just a concept that allows one to specify how one link moves with respect to another one. For example, a hinge joint of a door allows it to move relative to the fixed wall about an axis. No other motion is possible. Type of relative motion permitted by a joint is governed by the form of the contact surface between the members, which can be a surface, a line, or a point. Accordingly, they are termed as either 'lower' or 'higher' pair joint. If two mating links are in surface contact, the joint is referred to as a lower pair joint. On the contrary, if the links are in line or point contact, the

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About Lesson

Introduction to robot architecture

A robot is made up of several links connected serially by joints. The robot's degree of freedom (DOF) depends on the number of links and joints, their types, and the kinematic chain of the robot.

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About Lesson

Manipulators & End Effector

A manipulator in robotics is a tool used to move materials without the user making any direct physical touch. Originally, the applications were employed inaccessibly or to handle radioactive or biohazardous objects with robotic arms. In more recent advances, they have been used in a variety of applications, including robotic surgery, welding automation, and space travel.

Manipulators are composed of an assembly of links and joints. Links are defined as the rigid sections that make up the mechanism and joints are defined as the connection between two links. The device attached to the manipulator which interacts with its environment to perform tasks is called the end-effector.

About Lesson

What’s a robot manipulator ?

A robot manipulator is an electronically controlled mechanism, consisting of multiple segments, that performs tasks by interacting with its environment. They are also commonly referred to as robotic arms. Robot manipulators are extensively used in the industrial manufacturing sector and also have many other specialized applications (for example, the Canadarm was used on
space shuttles to manipulate payloads). The study of robot manipulators involves dealing with the positions and orientations of the several segments that make up the manipulators.

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About Lesson

Classification based on Kinematic Structure

Open-loop manipulator (or serial robot):

A manipulator is called an open-loop manipulator if its links form an open-loop chain.

Parallel manipulator:

A manipulator is called a parallel manipulator if it is made up of a closed-loop chain.

Hybrid manipulator:

A manipulator is called a hybrid manipulator if it consists of open loop and closed loop chains

About Lesson

Classification based on Motion Characteristics

Planar Manipulator:

A manipulator is called a planar manipulator if all the moving links move in planes parallel to one another.

Spherical Manipulator:

A manipulator is called a spherical manipulator if all the links perform spherical motions about a common stationary point.

Spatial Manipulator:

A manipulator is called a spatial manipulator if at least one of the links of the mechanism possesses a general spatial motion.

About Lesson

What is DOF?

The term degrees of freedom is widely used to define the motion capabilities of robots, including androids (humanoid robots). In this context, the term generally refers to the number of joints or axes of motion on the robot.

The number of degrees of freedom of a mechanism are defined as the number of independent variables that are required to completely identify its configuration in space. The number of degrees of freedom for a manipulator can be calculated as:

$$n_{dof} = \lambda(n-1) - \sum_{i=1}^{k}(\lambda - f_i)$$

... Eq. (1)

where n is the number of links (this includes the ground link), k is the number of joints, f_i is the number of degrees of freedom of the i^{th} joint and λ is 3 for planar mechanisms and 6 for spatial mechanisms.

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About Lesson

Homogenous Transformation

In robotics, Homogeneous Transformation Matrices (HTM) have been used as a tool for describing both the position and orientation of an object and, in particular, of a robot or a robot component.

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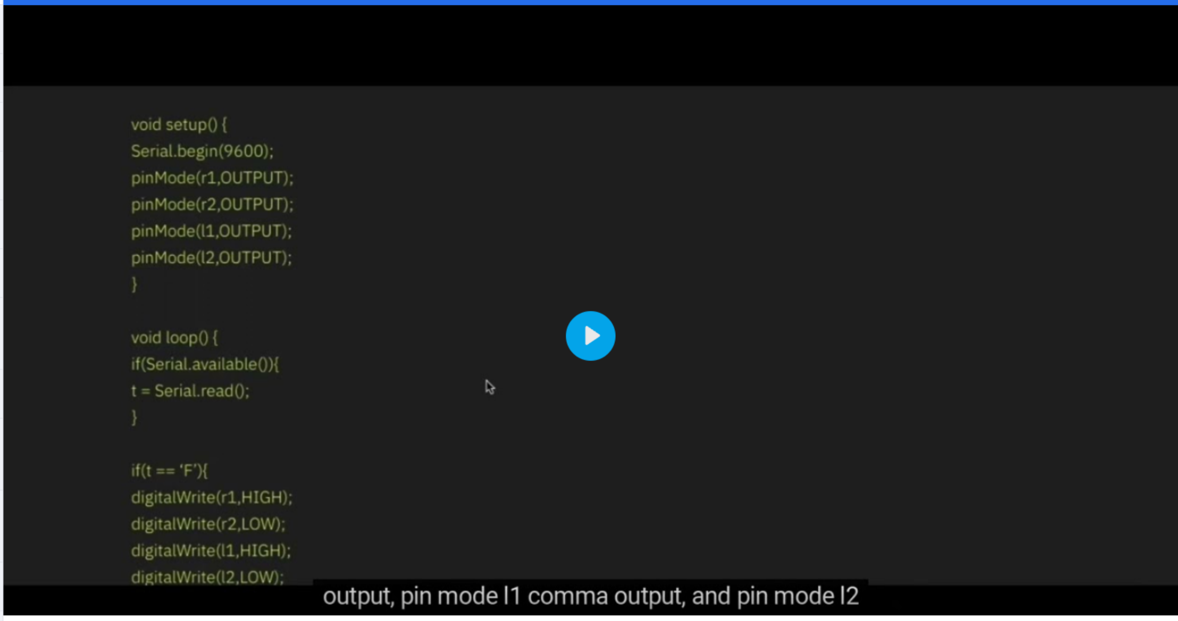

About Lesson

Code:

```
char t;
const int r1=2,r2=3,l1=4,l2=5;

void setup() {
Serial.begin(9600);
pinMode(r1,OUTPUT);
pinMode(r2,OUTPUT);
pinMode(l1,OUTPUT);
pinMode(l2,OUTPUT);
}

void loop() {
if(Serial.available()){
t = Serial.read();
}

if(t == 'F'){
digitalWrite(r1,HIGH);
digitalWrite(r2,LOW);
digitalWrite(l1,HIGH);
digitalWrite(l2,LOW);
}

else if(t == 'B'){
digitalWrite(r1,LOW);
digitalWrite(r2,HIGH);
digitalWrite(l1,LOW);
digitalWrite(l2,HIGH);
}

else if(t == 'L'){
digitalWrite(r1,HIGH);
digitalWrite(r2,LOW);
digitalWrite(l1,LOW);
digitalWrite(l2,HIGH);
delay(100);
t = 'S';
}

else if(t == 'R'){
digitalWrite(r1,LOW);
digitalWrite(r2,HIGH);
digitalWrite(l1,HIGH);
digitalWrite(l2,LOW);
delay(100);
t = 'S';
}
}
```

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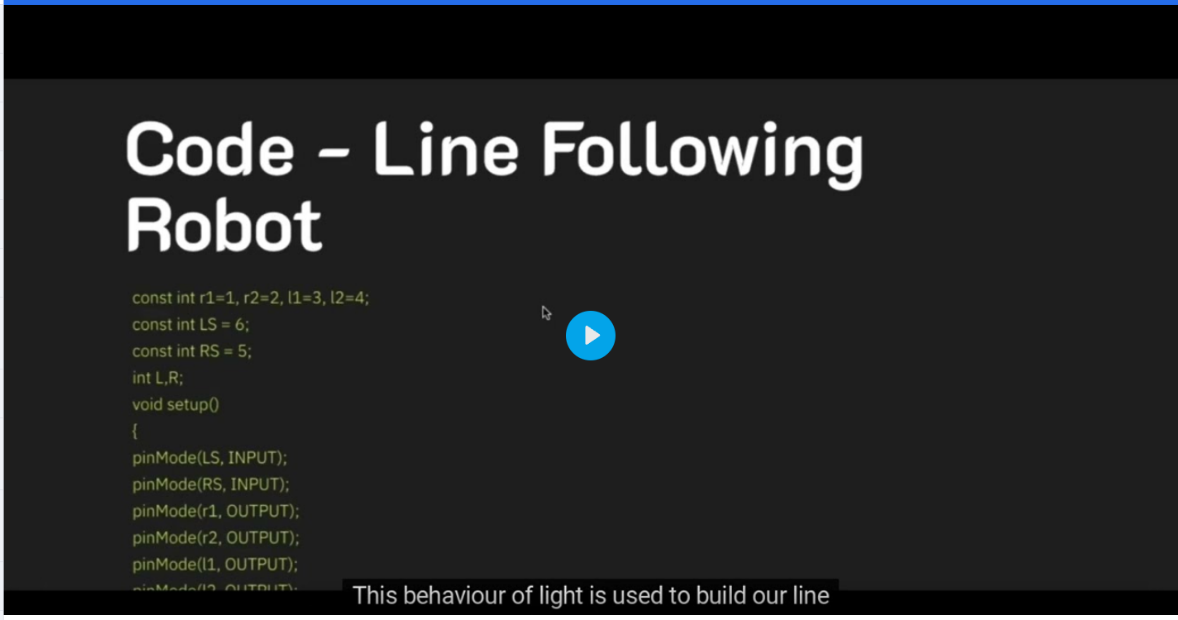

About Lesson

Code

```
const int r1=1, r2=2, l1=3, l2=4;
const int LS = 6;
const int RS = 5;
int L,R;
void setup()
{
pinMode(LS, INPUT);
pinMode(RS, INPUT);
pinMode(r1, OUTPUT);
pinMode(r2, OUTPUT);
pinMode(l1, OUTPUT);
pinMode(l2, OUTPUT);
digitalWrite(r2,LOW);
digitalWrite(l2,LOW);
}
void loop()
{
L = digitalRead(LS);
R = digitalRead(RS);
digitalWrite(r1, !R);
digitalWrite(l1, !L);
}
```

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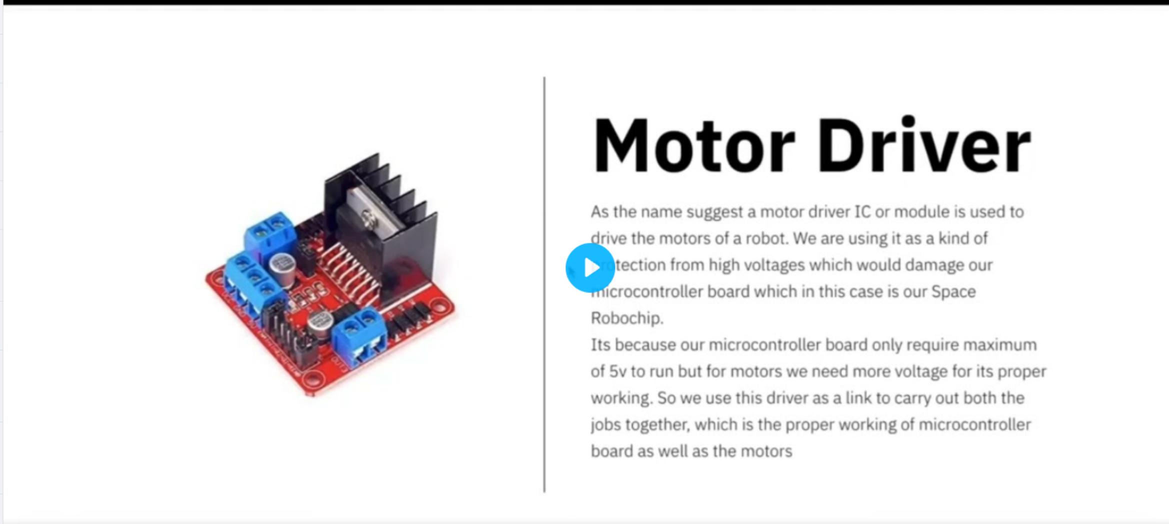

About Lesson

Documentation – Motor Driver

As the name suggest a motor driver IC or module is used to drive the motors of a robot. We are using it as a kind of protection from high voltages which would damage our microcontroller board which in this case is our Space Robochip.

Its because our microcontroller board only require maximum of 5v to run but for motors we need more voltage for its proper working. So we use this driver as a link to carry out both the jobs together, which is the proper working of microcontroller board as well as the motors

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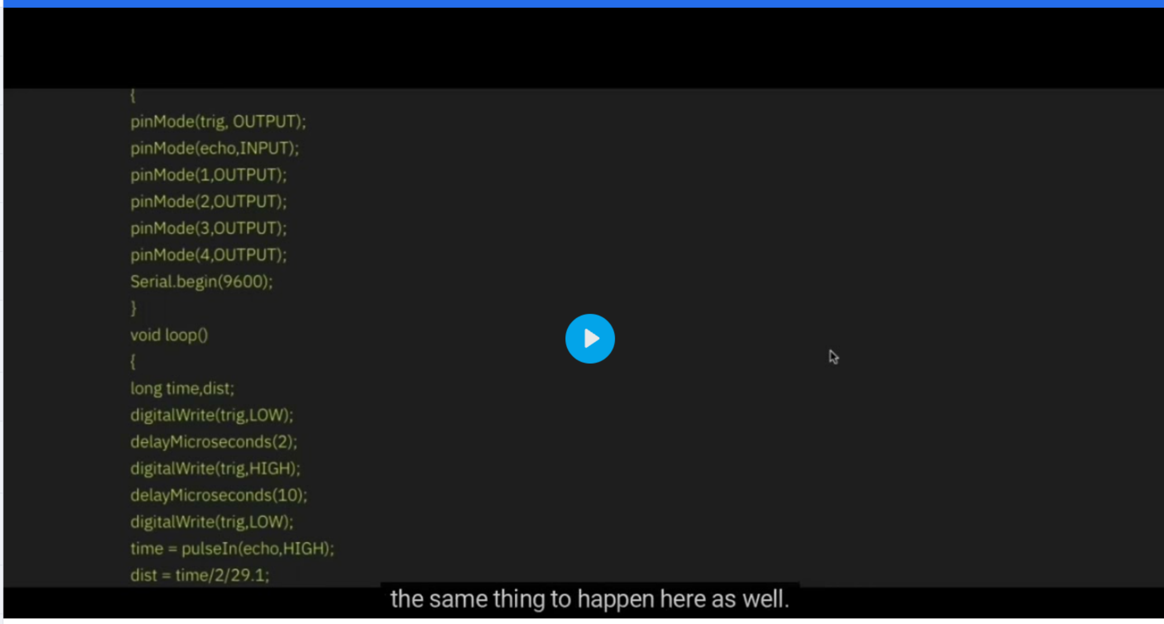


About Lesson

Code:

```
#define echo 5
#define trig 6
#define led 13
void setup()
{
pinMode(trig, OUTPUT);
pinMode(echo,INPUT);
pinMode(1,OUTPUT);
pinMode(2,OUTPUT);
pinMode(3,OUTPUT);
pinMode(4,OUTPUT);
Serial.begin(9600);
}
void loop()
{
long time,dist;
digitalWrite(trig,LOW);
delayMicroseconds(2);
digitalWrite(trig,HIGH);
delayMicroseconds(10);
digitalWrite(trig,LOW);
time = pulseIn(echo,HIGH);
dist = time/2/29.1;
Serial.println(dist);
delay(1000);
if (dist<100)
{
digitalWrite(1,LOW);
digitalWrite(2,LOW);
digitalWrite(3,LOW);
digitalWrite(4,LOW);
}
else
{
digitalWrite(1,HIGH);
digitalWrite(2,LOW);
digitalWrite(3,LOW);
digitalWrite(4,HIGH);
}
}
```

Ultrasonic Sensor

An **ultrasonic sensor** is an electronic device that measures the distance of a target object by emitting **ultrasonic** sound waves.Usually a normal ultrasonic sensor will have 4 pins. In order to generate the ultrasound we need to set the **Trigger Pin** on a **High** State for **10 microseconds**. That will send out an 8 cycle sonic burst which will travel at the speed sound and it will be received in the Echo Pin. The Echo Pin will **output** the **time** in microseconds the sound wave traveled.

Experiment Connections:

About Lesson

Documentation – Ultrasonic Basics

An ultrasonic sensor is an electronic device that measures the distance of a target object by emitting ultrasonic sound waves.Usually a normal ultrasonic sensor will have 4 pins.

In order to generate the ultrasound we need to set the Trigger Pin on a High State for 10 microseconds. That will send out an 8 cycle sonic burst which will travel at the speed sound and it will be received in the Echo Pin. The Echo Pin will output the time in microseconds the sound wave traveled.

Experiment Connections:

- Vcc to 5V of Space Robochip
- Trig to Digital Pin 5 of Space Robochip
- Echo to Digital Pin 6 of Space Robochip
- GND to GND of Space Robochip

Code:

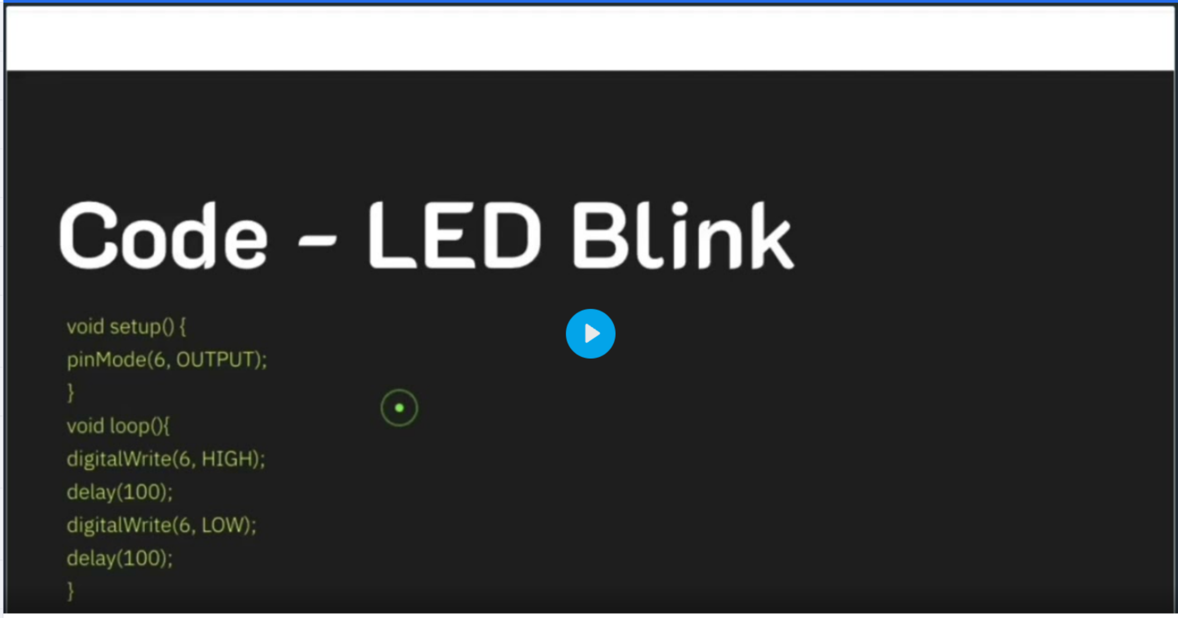
```
const int trigPin = 5;
const int echoPin = 6;

float duration, distance;

void setup() {
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
Serial.begin(9600);
}

void loop() {
digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);
distance = (duration*.0343)/2;
Serial.print("Distance: ");
Serial.println(distance);
delay(100);
}
```



About Lesson

Library – LED Experiment

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current is passed through it.

In this experiment we have connected the positive end to digital pin 6 of our microcontroller board. As well as we will connect the negative pin of LED to GND of our microcontroller board.

Positive(+) to Digital Pin 6

Negative(-) to GND

Code:

```
void setup() {
pinMode(6, OUTPUT);
}
void loop(){
digitalWrite(6, HIGH);
delay(100);
digitalWrite(6, LOW);
delay(100);
}
```

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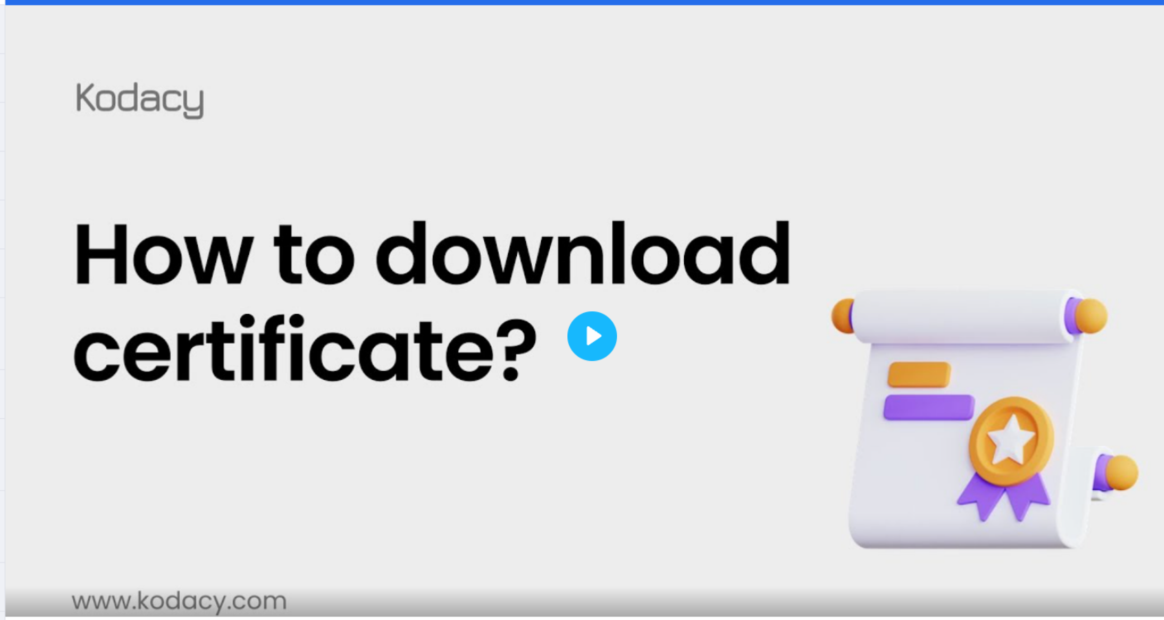

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AI Debug

```
void setup(){
pinMode(6,OUTPUT);
}
void loop(){
digitalWrite(6,HIGH);
delay(100);
digitalWrite(6,LOW);
delay(100);
}
```

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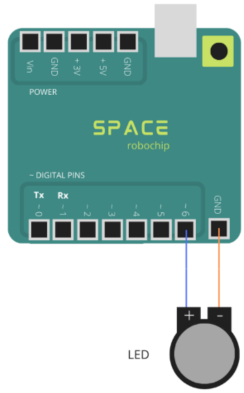

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