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Department for language studies

PROFESSIONAL ORIENTED FOREIGN LANGUAGE

Methodological recommendations for practical use, for students of specialty 5B070200 – Automation and control

Almaty 2018

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This guideline is written to develop skills in reading and translating technical texts in the field of Automation and control. It includes professionally oriented text material, exercises and tasks for mastering terms and information on this specialty.

Reviewer: candidate of Philology, assistant professor V. Kozlov

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PROFESSIONAL ORIENTED FOREIGN LANGUAGE

Methodological Recommendations for practical use, for students of specialty
5B070200 – Automation and Control

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Алматы 2018

Text 1

Industrial robot trends and types

doomed to fail - обречены на провал
sea turtles - морские черепахи
hatched – вылупились
hazards – опасность
neglected market – запущенный рынок
off-the-shelf range sensor - имеющийся в наличии датчика диапазона
a swap – подкачка
terrain conditions - условия местности
beyond placement - помимо размещения
a booth for grading - стенд для сортировки
pruning – обрезка
insecticide or nutrients - инсектицид или питательные вещества
evaluate – оценивать
warehouse – склад
yield – урожай
Ripen – созревать
scarcity issues - вопросы дефицита
sustainable – устойчивый
tug – буксир
lavish attention – большое внимание
surge – волна
alongside people - рядом с людьми
scoop – собирать
nursery – питомник
canopy – навес, тент

Robots are used in many industries including 3D printing, amusement parks, agriculture, assembly, construction, electronics, entertainment and theater (actor, props, set, and stage motion control), logistics and warehousing, manufacturing, medical, mining, transportation (self-driving vehicles), space exploration, sports (robotic cameras), and toys, among others.

Robotic design innovations and end effector ingenuity applied in one industry can be adapted for other industries. Many robotic contests, in many industries, inspire engineering minds of any age for education, fun, service, and technology advancement. High-profile efforts have aimed to adapt robots for firefighting, search and rescue, monitoring and inspection, and disaster prevention in hazardous locations (such as navigating to and turning off a valve where it is too dangerous to send humans).

In manufacturing, safety and prevention of lifting and repetitive injuries are among factors improving return on investment (ROI) calculations. See related links online (and the next article in print on ROI, with more on mobile robotics).

Checklist for robotic survival

Robot designers who ignore one or more of three principles are doomed to fail, according to a roboticist with 22 patents who has worked for three robot companies and MIT Robotic Lab. Joseph L. Jones, co-founder and chief technology officer, Harvest Automation, told attendees at the Robotics Industries Forum about a checklist for robot survival.

"How are robots like sea turtles? For each 1,000 sea turtles hatched, only one lasts to adulthood. It's about the same statistic for robots. Robot designers need to be really careful in choosing which robots to build," Jones said. He also worked at iRobot (which has sold 9 million Roomba robotic vacuums) and at Denning Mobile Robotics. In 30 years of watching the robotic industry, he's observed three key elements that need to be present with any robot project for success.

Checklist for robot survival

To create a successful robot, Jones said the robot should:

1) Do something that lots of people want done

2) Be built with existing technology, and

3) Be cost-competitive with current solutions.

While this seems perfectly logical, when in the thick of things, roboticists usually ignore one and often all three, Jones said, in his 30 years of observations. In his talk, "Small Mobile Robots for Agriculture" Jones discussed his current efforts at Harvest Automation, founded in 2007, now with 40 employees. He's making robots for agriculture. A nursery and greenhouse (N&G) robot is the company's first product.

Plants sold in garden stores often are grown in pots in open fields that extend to the horizon. Armies of hard-to-find workers manually space pots in the field after the pots are unloaded from wagons.

"After I observed that, I thought, 'If we cannot build a cost-effective robot to do this, we're in the wrong business,' Jones said.

Six systems challenge mobile robots

With any mobile robotic design, there are six system challenge areas: application system (sensors, actuators, and software), navigation, hazards, mobility, power, and the interface (for the HV-100 the application system consists of the gripper, the laser ranger that identifies the pots, and the software associated with pickup and putdown, he said).

Application notes: N&G work involves a lot of pain, with repetitive heavy lifting, Jones said; required seasonal labor is scarce and 80% undocumented. It's also inefficient, Jones noted. For this project, no research grants were needed. Picking up the pot required a one-degree-of-freedom manipulator. No GPS or cameras are used. A sensor consisting of a pair of photo diodes is used to find the yellow tape border guide; an off-the-shelf range sensor locates the pots. No inter-robot communication is needed to grab a pot and add it to the pattern in order. Batteries require a swap in 3-5 hours, depending on plant weight and terrain conditions.

Three years of development has led to the delivery of the first products to a customer in Georgia. A robot supervisor adjusts the user interface when needed and moves the boundary marker. Beyond placement, future capabilities will accommodate plant maintenance, putting the pot into a booth for grading, pruning, and targeted application of insecticide or nutrients (avoiding risk of human contact with whirling blades or hazardous chemicals).

Seek a large, neglected market

"We kept the design as small and simple as possible and tried to find a large and neglected market," Jones said. Several companies have proposed orange-picking robots, but that would be higher complexity and just a $2.5 billion market compared to N&G at $17 billion, he cited.

In general, when considering a robot, it's often helpful to reimagine the task. Consider the numerous design differences between an often vertical human-operated vacuum and a Roomba vacuuming robot from iRobot, which looks more like a large hockey puck with one button on top.

How can applications be found for robots? Roboticists usually don't know specific industry details. Potential customers usually don't know robots can help. To find opportunities, brainstorm, be opportunistic, and visit promising sites. Evaluate the applications with large market sizes and customer needs, simple technologies, and low cost.

Good examples include the Roomba, with 9 million units sold; the Kiva warehouse robot; and the Aethon hospital tug that pulls cabinets around for nurses, saving valuable staff time and effort.

Reimagining agriculture

There will be other agricultural applications with the anticipated global population increases. From now to 2050 we have to increase food production by 70% without more land or more water than used today. To increase yield, consider the giant vegetables displayed at county fairs. They get to be giant-sized because of lavish attention given to them. Robots may help optimize crops, supplying the missing labor. Selective pruning and hexagonal planting, impossible with traditional tractor wheels, may increase yield by 15% for some crops. Polyculture crops (multiple species in one field) can reduce pests and improve soil use, with fewer pesticides. Use of robots also may permit multiple harvests, taking fruit only at its peak and allowing immature fruit to continue to ripen. Robots could optimize crop growth; minimize and localize pesticide, water, and nutrient use; work safely with farmers; and avoid harmful soil compaction (compact soil increases water runoff and eliminates aeration).

First model, Harvest Automation HV100, costs about $30,000, with return on investment after 12-18 months of use, Jones said.

Robots are powering the next innovation surge in agriculture, Jones said. Harvest Automation, backed by a team of robotics innovators, has engineered the first practical, scalable robots for a range of agricultural applications starting with nursery and greenhouse operators, Jones explained. Addressing labor scarcity issues, Harvest's robots are designed to work alongside people, not replace them, in a grower's operation, to create a sustainable workforce combining robots and people to increase efficiency, reliability, and plant quality, he noted.

Mark T. Hoske, content manager, CFE Media, *Control Engineering* and *Plant Engineering*, mhoske@cfemedia.com.

1.Answer the questions:

*1)*Where are robots used?

2)What are three principles that need to be present with any robot project for success?

3)What are six system challenge areas?

4) How can applications be found for robots?

5) What kind of robots are Roomba and Aethon?

6) What should engineers do to increase yield?

7) Which advantages of using robots in agriculture can you name?

2. Complete the summary of the text:

labor	pots	diodes	manually	success	hazards	production	nursery

There are three key elements that need to be present with any robot project for ___ (1). Plants sold in garden stores often are grown in ___ (2) in open fields that extend to the horizon. Armies of hard-to-find workers ____ (3) space pots in the field after the pots are unloaded from wagons. With any mobile robotic design, there are six system challenge areas: application system (sensors, actuators, and software), navigation, ____ (4), mobility, power, and the interface. A sensor of the robot consisting of a pair of photo____ (5) is used to find the yellow tape border guide; an off-the-shelf range sensor locates the pots. From now to 2050 we have to increase food ____ (6) by 70% without more land or more water than used today. Robots may help optimize crops, supplying the missing ____ (6). Harvest Automation, backed by a team of robotics innovators, has engineered the first practical, scalable robots for a range of agricultural applications starting with ____ (7) and greenhouse operators.

3. Watch the video: "Harvest Automation About Us". Complete the gaps:

1) Industrial robots are widely used in industries like ____ manufacturing and semiconductor bridge.

2) The first market that we are addressing is ____.

3) To make agriculture a ____ in the country we have to automate.

4) We decided that it was time to start a new robot company that would do something different in the nursery and ____ sector.

5)The way that we program these robots is using a system called behavior – based ____ programming.

6) We describe our robots platform as ____ , practical and sustainable.

7) They can gather ____ while they do that work.

8) We have had over ____ years and will continue to do this.

9) When the future going forward we think there are industries like agriculture, like ____, like mining, like warehousing distribution.

4.Watch the video: "KSTP/ABC Bailey Nursery Uses Harvest Automation Robots for Time Consuming, Dull Job" and answer the questions:

1) What is the height of the robot?
2) What are the main functions of the robot?
3) Why is the robot equipped with eye?
4) Is it beneficial or catastrophic for employee to use this robot?

5.Match two parts to make sentences:

OmniVeyor HV-100

1) Harvest Automation's products	a) reduce production costs as well as increasing overall productivity
2) Harvest Automation's first product is	b) develop a uniform and consistent canopy
3) OmniVeyor HV-100 units are designed	c) spacing containerized plants, common to wholesale Nursery and Greenhouse operations
4) The robots are intended to	d) the OmniVeyor HV-100, providing automated material handling for the $14B Nursery and Greenhouse market
5) OmniVeyor HV-100 robots automate the task of	e) conserve resources such as land, water and pesticides

6) When plants are young they are placed in close proximity to one another on fields in order to	f) are branded under the OmniVeyor product line
7) As the plants grow their containers must be spaced apart to allow the plants to	g) been completed with manual labor
8) The task of spacing plants has historically	h) for operation in both indoor and outdoor environments as typically seen on wholesale greenhouses, hoop houses and nurseries

Text 2

Motion controls inside Cirque du Soleil's KÀ

instantaneous redundancy backup propels - двигатели мгновенного резервирования
flip – кувыркаться
tilt – наклон
motion control retrofit - модернизация управления движением
redundancy – избыточность
brake maintenance - техническое обслуживание тормозов
pegs - колья,
proximity sensors - датчики приближения
allusion – намек, ссылка
ripples of light – рябь, пульсация света
arrow strikes – удар стрелы
stroke – ход поршня
pump – насос
to disengage – разъединиться, выключать
vendor – поставщик
shutdowns – закрытие, остановка
implement – осуществлять
hydraulic servo - гидравлический сервопривод
control valves - регулирующие клапаны
plausibility test - проверка достоверности
closed-loop position control - управление положением в замкнутом контуре
backup – резервный, дублирующий
smoothness – гладкость, плавность
filtering and tuning optimization - оптимизация фильтрации и настройки
bounce – отскок, энергия
programmed speed override - запрограммированное регулирование скорости

Application Update: Motion control with instantaneous redundancy backup propels the Cirque du Soleil production of KÀ, at the MGM Grand Hotel & Casino, Las Vegas. The production includes a 140-ton stage that rises from below ground level, tilts 180 degrees, and rotates 360, while acrobatic actors fly, flip, dance, climb, fight, fall, and operate puppets while the stage is in various positions from horizontal to vertical.

The Cirque du Soleil production of KÀ at the MGM Grand Hotel & Casino, Las Vegas, has motion controls with instantaneous redundancy backup to propel the a 140-ton stage that rises from below ground level, tilts 180-deg and rotates 360 while acrobatic actors fly, flip, dance, climb, fight, fall, and clown over and around it, still and in motion from horizontal to vertical. The stage has about 30 moves per show and has performed reliably since a 2007 motion control retrofit.

Ian Hall, product and application consulting director, Siemens Industry Inc., Digital Factory Division, explained that Siemens consulted with MGM after the show missed several performances because of lack of system redundancies. Also, brake maintenance was high, with the first system, which also didn't include speed control.

Production, retrofit details

Hall offered the following details about the production and motion control retrofit.

1)Cast is more than 300; 80 artists appear on stage; about 80 more work behind the scenes.

2)With the stage near vertical, 80 pegs emerge in various locations, using proximity sensors to avoid human contact while emerging or disappearing, synchronized to provide the allusion of warriors fighting on a cliff.

3) A projection screen makes the surface a touch sensor for some scenes, reacting with ripples of light to actors' feet and simulating arrow strikes.

4) McLaren Engineering did the original design, including hydraulics with 4,000 gallons of vegetable oil (now mineral oil is used).

5) The platform moves 70 ft at 2 ft/sec, using 4 hydraulic cylinders with a 70-ft stroke. Downward speed is limited to 1 ft/sec for safety. Five 250 hp pumps feed the piston accumulators that produce 6,000 hp. The pumps, running at 1,500 psi, and accumulators are about 1000 m away from the stage, feeding the hydraulic cylinders via pipes at 770 psi pressure.

6) The original design had perhaps 30 single points of failure, including encoders and controllers. Brake maintenance was high, since brakes were used at every stop, about 30 per show, two shows per day. Move commands required 16 seconds of lead time because brakes had to disengage and pumps had to increase pressure. Left to right balance wasn't always stable. Several shows were lost from system failure using the first design. More redundancy was needed.

7) The automation vendor provided project management and engineering support for the retrofit and motion system upgrade, over a year and a half, with most

work during schedule shutdowns. Study began in 2005. In 2007 the solution was implemented and the production had two control systems until the new one was ready, tested, and approved.

8) New system has only one or two single points of failure (including hydraulic servo control valves).

9) The motion controller voting system uses a plausibility test for each move to ensure controllers agree that a move should be made.

10) In the new design, brakes are only engaged once. Hydraulic pressure control maintains position control, keeping the stage in position design actors' weight and action.

11) Instead of a 16-second cycle, closed-loop position control provides a response rate measured in milliseconds.

12) A Profibus network is used for motion control; an Ethernet network mirrors communications and serves as a backup. Profibus is represented by PI North America.

13) Smoothness of ride was notable after national frequency of the stage and non-linear nature of the application were taken into account by applying filtering and tuning optimization. (Taller column of fluid created more bounce.)

14) Programmed speed override is possible if a timing adjustment is needed. Full reset takes 20 seconds and left to right balance is within one-half inch.

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1. Complete the summary of the text:

vendor	reliably	stage	instantaneous

A retrofit motion control project to create ____ (1) redundancy backups for the Cirque du Soleil production of KÀ, at the MGM Grand Hotel & Casino, Las Vegas, has performed ____ (2) since its 2007 installation. The production includes a 140-ton ____ (3) that rises from below ground level, tilts 180 degrees, and rotates 360 degrees. The automation ____ (4) served as the primary contractor on the retrofit project.

2. Answer the questions:

1) What does the Cirque du Soleil production of KÀ, at the MGM Grand Hotel & Casino, Las Vegas propel?

2) What does the production include?

3)Why did show miss several performances?

4) Why was brake maintenance high?

5) Why do 80 pegs emerge in various locations with the stage near vertical?

6) What did the original design of McLaren Engineering include?

7) What are the technical characteristics of platform?

8) How many did the original design have single points of failure, including encoders and controllers? Describe some of them.

9) Who provided project management and engineering support for the retrofit and motion system upgrade, over a year and a half, with most work during schedule shutdowns?

10) How many points of failure does new system have?

11) Why does the motion controller voting system use a plausibility test for each move?

12) How many times are brakes engaged in the new design?

13) Which response rate does closed-loop position control provide?

14) Which network is used for motion control?

15) What mirrors communications and serves as a backup?

16) What were taken into account by applying filtering and tuning optimization?

17) In which condition is programmed speed override possible?

18) What time does it take for full reset?

3. Consider this:

How could a motion control retrofit provide greater reliability through redundancy, smoother movements, and precise position control to an existing application?

Text 3

New Mars Rover Curiosity is bigger, better, more efficiently designed

Jet Propulsion Laboratory - лаборатория реактивного движения
to enhance – повысить, совершенствовать
CEO (chief executive officer) - генеральный директор
dawning – рассвет
a tangible example - осязаемый пример
curiosity – любопытство
rover – скиталец
paving the way – прокладывая путь
to withstand – выдерживать
simulate - моделировать
deploy – развертывать
hovering stop – остановка при зависании
pursue – продолжать, заниматься
holistic – целостный
acquire – приобретать
major feat – главный подвиг

NASA enters a new era in space exploration: NASA's Jet Propulsion Laboratory (JPL) using Siemens software shows how modern software technology is being employed to enhance competitiveness in the aerospace industry

NASA director Doug McCuistion and Siemens Industry CEO Siegfried Russwurm discussed the dawning of a new era of space exploration and the critical roles that NASA engineers and Siemens software technology play in helping to make it possible. The two companies, in a joint July 10 press conference, referenced the impending Aug. 5 landing of the latest Mars Rover *Curiosity*—designed by NASA's Jet Propulsion Laboratory (JPL) using Siemens software—as a tangible example of how modern software technology is being employed to enhance competitiveness in the aerospace industry. Part of this ongoing transformation includes public-private partnerships and a constant drive to maximize productivity and shorten development times.

"*Curiosity* is the most sophisticated rover ever sent to Mars, and will further enhance our understanding of the Red Planet while paving the way for future human exploration," said Doug McCuistion, NASA director of the Mars Exploration Program.

"The incredible team of scientists and engineers at NASA's JPL has employed the latest in software technology to design the Mars Rover to withstand the impossible extremes of launch, space travel, atmospheric re-entry, and landing a 2000-lb operational vehicle on the surface of Mars."

Videos, takeoff and landing

JPL used product lifecycle management (PLM) software from Siemens throughout the development process to digitally design, simulate, and assemble the Rover before any physical prototypes were built. The software helped to ensure all components would fit together, operate properly, and withstand whatever environment the mission would require. During entry through Mars' atmosphere, which is known to JPL scientists as Seven Minutes of Terror: The capsule will slow from 13,000 miles per hour to zero:

1) External temperatures will peak at over 1,500 degrees Celsius.

2) Curiosity will deploy the largest and strongest supersonic parachute ever built to "catch" over 65,000 pounds of force.

3)Precision, radar-guided rockets will maneuver the capsule to a full, hovering stop 20 meters above the surface.

4) The ship's sky-crane will lower Curiosity the final meters to a soft landing.

Simulating the Curiosity rover's final approach and landing was a major feat for everyone. NASA used Siemens PLM Software to account for the thousands of data points (in over half a million lines of code) to recreate the out-of-this-world conditions needed to test the final minutes of Curiosity's journey to Mars.

Half the time to market

“Siemens is proud of our strong partnership with NASA and the role our technology plays in helping them pursue such extraordinary and ambitious missions”, said Siegfried Russwurm, member of the Siemens Board and CEO of the Industry Sector. In the aerospace industry, Siemens’ overall revenues across all technologies are in the mid-three-digit-million Euro range. Russwurm highlighted the essential role of cost-efficient product design and production in aircraft manufacturing: “The aerospace industry is on the leading edge when it comes to managing the full complexity of sophisticated product development and manufacturing. With our unique Siemens combination of PLM software and automation technologies, we not only cut time to market by up to 50% but also save resources and energy costs”.

As a part of the Siemens vertical IT for industrial production, Siemens PLM software is used by more than 70,000 customers worldwide in aerospace, automotive, electronics, machinery, and other industries. Siemens said it is one of the world’s largest software companies with over 17,000 software engineers worldwide. The scope of vertical IT and software from Siemens comprises software and software-based solutions offered by all of its Sectors Energy, Healthcare, Industry, Infrastructure & Cities for their respective vertical industries. In its Industry Sector, Siemens has been successfully integrating PLM software with automation technologies since the company acquired UGS Corp. in 2007. In the following years, Siemens has continuously expanded its expertise for this growth market. The latest industry software companies Siemens has acquired are Active Tecnologia em Sistemas de Automação (pharmaceutical and biotech production), Vistagy Inc. (composite material design), IBS AG (quality and production management), and Innotec do Brasil (holistic plant management).

The use of Siemens PLM software for this project was mentioned at the Siemens Summit 2012.

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1. Answer the questions:

1)Why did the two companies, in a joint July 10 press conference, reference the impending Aug. 5 landing of the latest Mars Rover Curiosity—designed by NASA’s Jet Propulsion Laboratory (JPL) using Siemens software?

2) What does part of this ongoing transformation include?

3) What will *Curiosity* is the most sophisticated rover ever sent to Mars, enhance?

4) Why has the incredible team of scientists and engineers at NASA’s JPL employed the latest in software technology?

5) Why did JPL use product lifecycle management (PLM) software?

6) What did the software help to ensure?

7) When will the capsule slow from 13,000 miles per hour to zero?

8) Why will curiosity deploy the largest and strongest supersonic parachute ever built?

9) What will maneuver the capsule to a full, hovering stop 20 meters above the surface?

10) What will lower Curiosity the final meters to a soft landing?

11) Why did NASA use Siemens PLM Software to account for the thousands of data points (in over half a million lines of code)?

12) What are Siemens' overall revenues across all technologies in the aerospace industry?

13) Where is Siemens PLM software used?

14) What does the scope of vertical IT and software from Siemens comprises?

2. Complete the gaps in the text:

water	two-year	Canaveral	site	rover

Curiosity is a car-sized robotic ____ (1) exploring Gale Crater on Mars as part of NASA's Mars Science Laboratory mission (MSL). Curiosity was launched from Cape ____ (2) on November 26, 2011, at 15:02 UTC aboard the MSL spacecraft and landed on Aeolis Palus in Gale Crater on Mars on August 6, 2012, 05:17 UTC. The Bradbury Landing ____ (3) was less than 2.4 km (1.5 mi) from the center of the rover's touchdown target after a 560 million km (350 million mi) journey. The rover's goals include: investigation of the Martian climate and geology; assessment of whether the selected field site inside Gale Crater has ever offered environmental conditions favorable for microbial life, including investigation of the role of ____ (4); and planetary habitability studies in preparation for future human exploration.

Curiosity's design will serve as the basis for the planned Mars 2020 rover. In December 2012, *Curiosity*'s ____ (5) mission was extended indefinitely. As of March 11, 2017, *Curiosity* has been on Mars for 1634 sols (1678 total days) since landing on August 6, 2012.

3. Watch the video and complete the gaps:

1) NASA's Mars rover "Curiosity" celebrates its ____ year on Mars since landing at Gate crater on August 5, 2012.

2) Four years of experience allows them to plan challenging and complex activities much ____.

3) in spite of the expected wear and tear curiosity is fully functional and as busy as ____.

4) Much of the past years was spent on an obstacle ____ of sorts on lower Mouth Sharp.

5) But the rover reached a sport where it could ____ around the dunes making a long-waited left turn.

6) The science team compared rock power drilled from the ____ with that drilled from unaltered rock.

7) Recently NASA gave curiosity the best anniversary gift it could hope for – an extension of its ____ for at least two more years.

Text 4

NASA Mars mission

Terrain – рельеф местности
Slippage – скольжение
Traverse – перемещение
non-fissile isotope – нерасщепляющийся изотоп
encounter – сталкиваться
radiation-hardened memory - радиационно-упрочненная память
power-off cycles – цикл выключения
rocker-bogie suspension - качающаяся подвеска
landing gear – шасси
predecessor – предшественник
pattern of grooves – шаблон бороздки
traction – тяга

The Mars Science Lab was launched on November 26, 2011, and is scheduled to land on Mars at Gale Crater on August 6, 2012. The rover Curiosity, after completing a more precise landing than ever attempted previously, is intended to help assess Mars' habitability for future human missions. Its primary mission objective is to determine whether Mars is or has ever been an environment able to support life.

Curiosity is five times as large as either of the Mars Exploration Rovers Spirit or Opportunity and carries more than ten times the mass of scientific instruments present on the older vehicles. The rover is expected to operate for at least 686 days as it explores with greater range than any previous Mars rover. Here are some of the specs that help set Curiosity apart from the other rovers.

The rover Curiosity is 3 meters in length, and weighs 900 kg, including 80 kg worth of scientific instruments. It is approximately the size of a Mini Cooper automobile.

Once on the surface, Curiosity will be able to roll over obstacles approaching 75 cm high. Maximum terrain-traverse speed is estimated to be 90 meters per hour by automatic navigation, however, with average speeds likely to be about 30 meter per hour depending on power levels, difficulty of the terrain, slippage, and visibility. It is expected to traverse a minimum of 12 miles in its two-year mission.

Curiosity is powered by a radioisotope thermoelectric generator, as used by the successful Mars landers Viking 1 and Viking 2 in 1976. Radioisotope power systems are generators that produce electricity from the natural decay of plutonium-238, which is a non-fissile isotope of plutonium. Heat given off by the natural decay of this isotope is converted into electricity, providing constant power during all seasons and through the day and night, and waste heat can be used via pipes to warm systems, freeing electrical power for the operation of the vehicle and instruments.

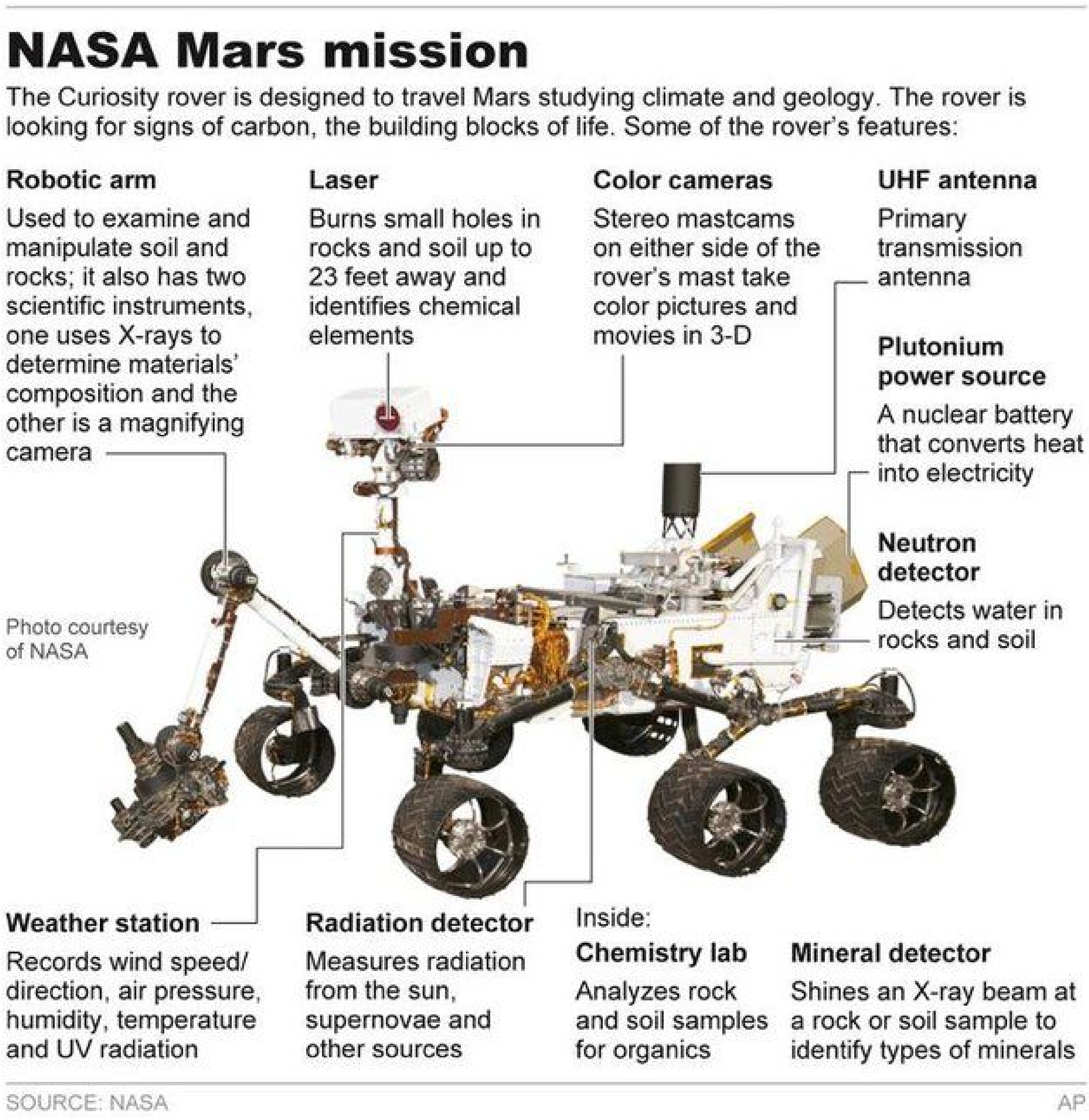


Figure 1

The temperatures that Curiosity can encounter vary from +30 to −127 °C. Therefore, the Heat rejection system uses fluid pumped through 60 meters of tubing in the MSL body so that sensitive components are kept at optimal temperatures.

The two identical on-board computers contain radiation-hardened memory to tolerate the extreme radiation environment from space and to safeguard against power-off cycles. Curiosity has two means of communication - an X-band transmitter and receiver that can communicate directly with Earth, and a UHF software-defined radio for communicating with Mars orbiters. Communication with orbiters is expected to be the main method for returning data to Earth, since the orbiters have both more power and larger antennas than the lander. At landing time, 13 minutes, 46 seconds will be required for signals to travel between Earth and Mars.

Like previous rovers Mars Exploration Rovers and Mars Pathfinder, Curiosity is equipped with 6 wheels in a rocker-bogie suspension. The suspension system will also serve as landing gear for the vehicle. Its smaller predecessors used airbag-like systems. Curiosity's wheels are significantly larger than those used on the previous rovers. Each wheel has a pattern of grooves that help it maintain traction, while leaving a distinctive track in Martian soil. That pattern, to be photographed by on-board cameras, will be used to judge the distance travelled.

1. Answer the questions:

1) When was the Mars Science Lab launched?
2) What is its primary mission objective?
3) What are the size and the parameters of Curiosity?
4) What is the speed of Curiosity?
5) What are Radioisotope power systems?
6) What is the function of the two identical on-board computers?
7) Which is main method for returning data to Earth?
8) Why is Curiosity equipped with 6 wheels in a rocker-bogie suspension?

2. Continue the sentences:

1) The rover Curiosity, after completing a more precise landing than ever attempted previously, is intended to …
2) Curiosity is five times as large as either of the Mars Exploration Rovers Spirit or Opportunity and carries more than …
3) The rover Curiosity is 3 meters in length, and weighs 900 kg, including…
4) Maximum terrain-traverse speed is estimated to be 90 meters per hour by automatic navigation, however, with average speeds likely to…
5) Curiosity is powered by a radioisotope thermoelectric generator, as used by…
6) Therefore, the Heat rejection system uses fluid pumped through 60 meters of tubing in…
7) The two identical on-board computers contain radiation-hardened memory to tolerate…
8) Curiosity has two means of communication - an X-band transmitter and receiver that can communicate directly with Earth, and…
9) Communication with orbiters is expected to be the main method for returning data to Earth, since…
10) Like previous rovers Mars Exploration Rovers and Mars Pathfinder, Curiosity is equipped with…
11) Each wheel has a pattern of grooves that help it maintain traction, while…

Text 5

Ten robotic software trends

malicious code – вредоносный код
vendor – поставщик
augmented – дополнены
error-proofing – защита от ошибок
replicate – копировать
wireless teach pendants – беспроводные обучающие подвесы
wizard – мастер
in a step-by-step flowchart roadmap - в пошаговой схеме дорожной карты

Robotic controllers are becoming smaller and less proprietary; even a programmable logic controller (PLC), programmable automation controller (PAC), industrial PC (IPC), PC, embedded controller, or motion controller from a nonrobot manufacturer can be used for robot control.

Advances in networking allow smoother communications and collaboration among other robots and other systems, working in a wider collaboration, advancing the goals of smart factory, Industrial Internet of Things (IIoT), and Industry 4.0 frameworks. Robotic software and robotic programming are becoming easier and more flexible in 10 ways:

1) Artificial intelligence (AI) allows past actions, or a downloaded historical database, to help a robot learn and adapt to new situations more quickly.

2) Cyber security conventions increasingly are becoming integrated in and around robots to ensure malicious code isn't introduced or unauthorized remote control is not allowed.

3) Function blocks, pieces of programming (code) representing certain robotic motions (kinematics), can be offered by the software vendor and augmented by the end user, original equipment manufacturer, machine builder, or system integrator.

4) Interactive sensory input and instructions can be transmitted from end effectors (tools or manipulators: the business end of the robot), sensors, and other devices and systems. Examples include machine vision or radio frequency identification chips embedded in tooling for additional automated operations, error-proofing, and higher quality, with ability to sense and compensate for tool wear.

5) Open-source programming allows software to be used across multiple vendors' robots.

6) Move-to-teach functions allow some robots to be guided along a path, learning along the way, perhaps asking when or if A to C is acceptable, rather than A to B to C; see also AI and wizards.

7) Simulations replicate robot and its environment in software, allowing full testing of end effectors, multiple robot or machine combinations, safety elements, and tasks, proving design and operation prior to implementation or purchase.

8) Universal programming software can import and integrate robotic kinematics (guiding robotic motion) in a unified process, from design through operation; see also simulation.

9) Wireless teach pendants provide more mobility than wired human-machine interfaces, including some robotic software that can be used on commercial tablets.

10) Wizards guide the robot tender or fleet manager through simplified programming without coding, in a step-by-step flowchart roadmap with pull-down choices, fill-in boxes, and prompts.

1. What robotic software and robotic programming:

a) allows software to be used across multiple vendors' robots;

b) can import and integrate robotic kinematics (guiding robotic motion) in a unified process, from design through operation; see also simulation;

c) allows past actions, or a downloaded historical database, to help a robot learn and adapt to new situations more quickly;

d) can be transmitted from end effectors (tools or manipulators: the business end of the robot), sensors, and other devices and systems;

e) guide the robot tender or fleet manager through simplified programming without coding, in a step-by-step flowchart roadmap with pull-down choices, fill-in boxes, and prompts;

f) are becoming integrated in and around robots to ensure malicious code isn't introduced or unauthorized remote control is not allowed;

g) allow some robots to be guided along a path, learning along the way, perhaps asking when or if A to C is acceptable, rather than A to B to C; see also AI and wizards;

h) can be offered by the software vendor and augmented by the end user, original equipment manufacturer, machine builder, or system integrator;

i) provide more mobility than wired human-machine interfaces, including some robotic software that can be used on commercial tablets;

j) can be offered by the software vendor and augmented by the end user, original equipment manufacturer, machine builder, or system integrator;

k) replicate robot and its environment in software, allowing full testing of end effectors, multiple robot or machine combinations, safety elements, and tasks, proving design and operation prior to implementation or purchase.

Text 6

Nine industrial robot types

articulated robot - сочлененный робот
cartesian coordinate robot - декартово координатный робот
gantry – портальный
articulated - шарнирно-сочлененный
cartesian - картезианский

torque - вращающийся момент
infeed – подача
rugged terrain – пересеченная местность
rotating lever – вращающийся рычаг
linear actuator – линейный привод

Industrial robot types vary and can include elements of more than one type. For instance, an articulated robot can be integrated with a gantry or mobile robot.

Nine industrial robot types and functions include:

1) Articulated robots have a rotating trunk, shoulder, bicep, forearm, and wrist. They can place small parts accurately and can pack and palletize.

2) Cartesian robots have at least three linear axes of control and can be configured for heavy operations (transporting auto body parts) or precise operations like creating detailed designs on a surface.

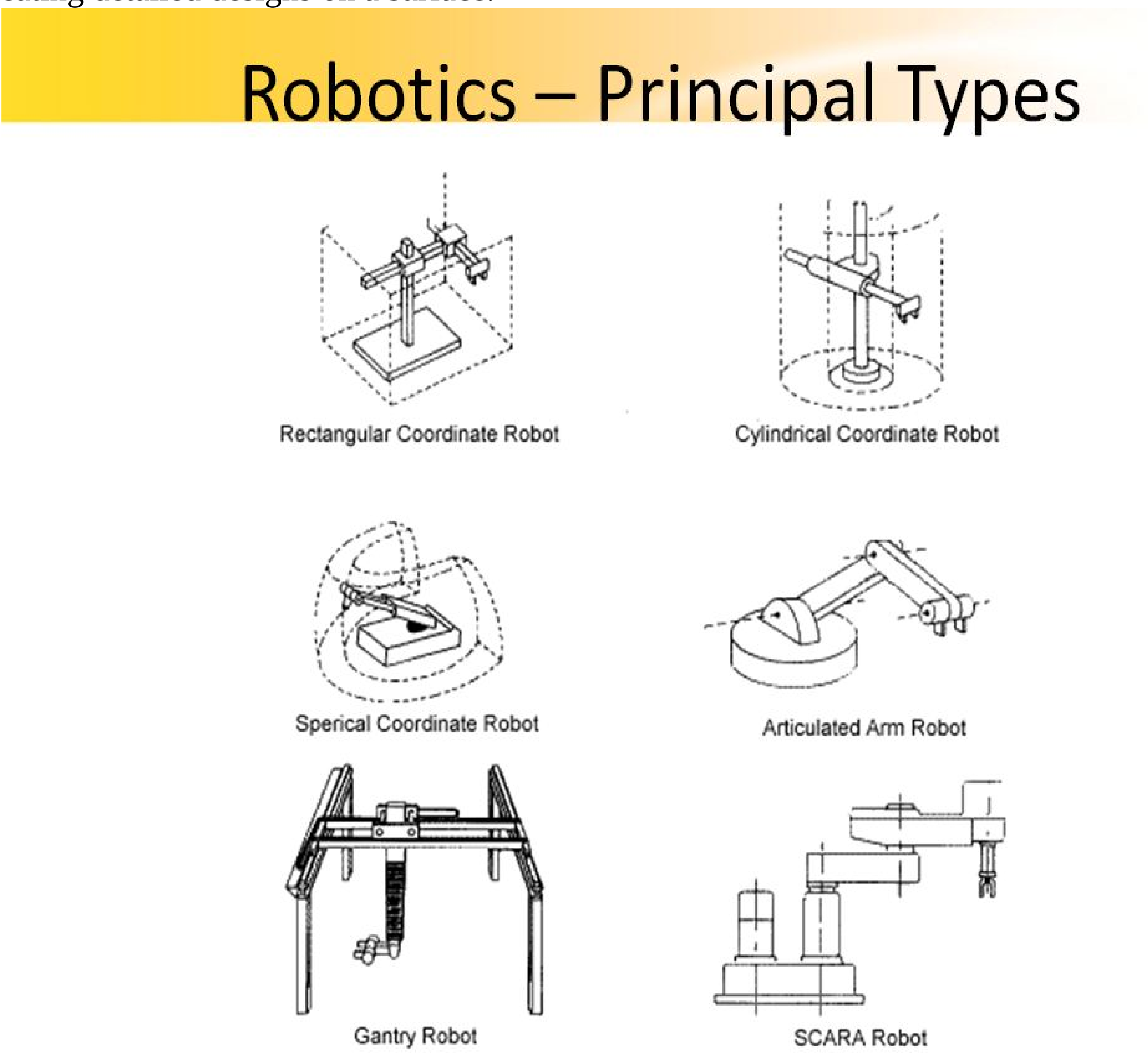


Figure 2

3) Collaborative robots are designed with force-limiting sensors and/or safe-speed and torque functions, so, depending on the application, they may be able to work in close proximity to humans without a safety enclosure. So far, these have been of the articulated robot design. Sensors can be applied to traditional robots, applying limits to speed and force when humans are near. Technology advances are moving faster than robotic safety tests and safety standards, although some guidance and advice for implementation are available in robotic safety documents, conferences, and articles. Some robots, with two-arm configurations, can take on humanoid attributes from the waist up; it may be more practical or desirable to adapt the robot to an existing process rather than adapt or redesign a process to adapt to traditional robot form factors.

4) Delta robots are a high-speed form of parallelogram robots for top loading and infeeds, used for packaging, pharmaceutical, assembly, and clean-room applications.

5) Drones, while mostly remote controlled at this point (so not truly robots), are being applied to industrial applications, such as safety inspection, monitoring, or scientific exploration, in hazardous locations, rugged terrains, underwater, and in space. More will gain autonomous capabilities, becoming mobile robots, reporting back or seeking instruction as needed.

6) Gantry robots are so-called because of the linear rail upon which they are mounted, providing (usually) overhead horizontal mobile access to a larger work area. This can offer another axis or two of motion and mobility to another robot type, such as an articulated robot, mounted to the gantry frame. Uses for gantry robots include pick and place, assembly, machine tending, and others. The same idea can be applied in vertical, circular (cylindrical), or polar (spherical) configurations.

7) Mobile robots, used for material transport, warehousing, fulfillment, and services, including machine tending, are rapidly expanding, as sensor and navigation technologies, combined with advance algorithms (programming), have increased their speed and flexibility. These can combine other motion capabilities and make autonomous navigation decisions beyond more traditional automated guided vehicles (AGVs) that may use tracks, guides, or tape for navigation.

8) Parallelogram robots use three parallelograms and rotating levers operated by servo motors or linear actuators. They often perform pick-and-place operations.

9) Selective compliant articulated robot arm (SCARA) robots, with arms rigid in the Z-axis and moveable in the X-Y axes, often perform assembly operations. SCARA robots can be faster than Cartesian robots and have a small footprint but are often more costly.

Mark T. Hoske, content manager, CFE Media, *Control Engineering*, mhoske@cfemedia.com.

1. Which robot:

a) are so-called because of the linear rail upon which they are mounted, providing (usually) overhead horizontal mobile access to a larger work area?

b) have a rotating trunk, shoulder, bicep, forearm, and wrist. They can place small parts accurately and can pack and palletize?

c) can be faster than Cartesian robots and have a small footprint but are often more costly?

d) have at least three linear axes of control and can be configured for heavy operations (transporting auto body parts) or precise operations like creating detailed designs on a surface?

e) are being applied to industrial applications, such as safety inspection, monitoring, or scientific exploration, in hazardous locations, rugged terrains, underwater, and in space?

f) are designed with force-limiting sensors and/or safe-speed and torque functions, so, depending on the application, they may be able to work in close proximity to humans without a safety enclosure?

g) can combine other motion capabilities and make autonomous navigation decisions beyond more traditional automated guided vehicles (AGVs) that may use tracks, guides, or tape for navigation?

h) are a high-speed form of parallelogram robots for top loading and infeeds, used for packaging, pharmaceutical, assembly, and clean-room applications?

i) often perform pick-and-place operations?

Text 7

Articulated robot

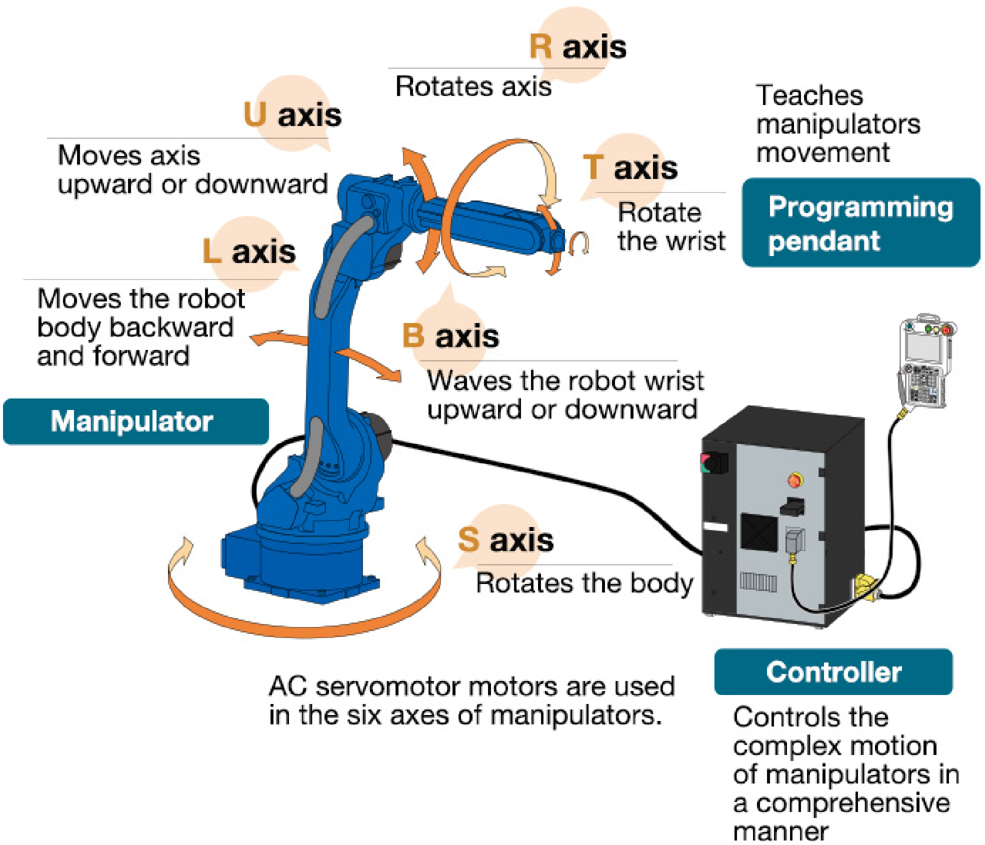


Figure 3

articulated robot - робот с шарнирными сочленениями, шарнирный робот

rotary joints - вращающиеся соединения
whereby - посредством которой
gripper - захват
maintaining rated precision - сохранение номинальной точности
grasp – захватывать
sweep – перемещаться
drive ratio - передаточное отношение

An articulated robot is a robot with rotary joints (e.g. a legged robot or an industrial robot). Most successful legged robots have four or six legs for further stability. This legs-over-wheels approach lends itself for use in all-terrain purposes because legs are more effective in an uneven environment than wheels. Articulated robots can range from simple two-jointed structures to systems with 10 or more interacting joints. They are powered by a variety of means, including electric motors. Some types of robots, such as robotic arms, can be articulated or non-articulated.

An articulated robot is one which uses rotary joints to access its work space. Usually the joints are arranged in a “chain”, so that one joint supports another further in the chain.

The articulated robot arm has a trunk, shoulder, upper arm, forearm, and wrist. With the ability to rotate all the joints, a majority of these robots have six degrees of freedom.

Axis 1 - Arm sweeps from side to side
Axis 2 - Shoulder moves forward and backward.
Axis 3 - Elbow moves up and down.
Axis 4 - Middle of forearm pivots up and down.
Axis 5 - Wrist moves up and down.
Axis 6 - Wrist sweeps from side to side.

Movement is made in three ways: pitch is up and down movement, yaw is right and left movement, and roll is rotation. This mobility allows articulated robots to be used for tasks such as welding, painting, and assembly.

Continuous Path: a control scheme whereby the inputs or commands specify every point along a desired path of motion. The path is controlled by the coordinated motion of the manipulator joints.

Degrees Of Freedom (DOF): the number of independent motions in which the end effector can move, defined by the number of axes of motion of the manipulator.

Gripper: a device for grasping or holding, attached to the free end of the last manipulator link; also called the robot’s hand or end-effector.

Payload: the maximum payload is the amount of weight carried by the robot manipulator at reduced speed while maintaining rated precision. Nominal payload is measured at maximum speed while maintaining rated precision. These ratings are highly dependent on the size and shape of the payload.

Pick And Place Cycle: pick and place Cycle is the time, in seconds, to execute the following motion sequence: move down one inch, grasp a rated payload; move up one inch; move across twelve inches; move down one inch; ungrasp; move up one inch; and return to start location.

Reach: the maximum horizontal distance from the center of the robot base to the end of its wrist.

Accuracy: the difference between the point that a robot is trying to achieve and the actual resultant position. Absolute accuracy is the difference between a point instructed by the robot control system and the point actually achieved by the manipulator arm, while repeatability is the cycle-to-cycle variation of the manipulator arm when aimed at the same point.

Repeatability: the ability of a system or mechanism to repeat the same motion or achieve the same points when presented with the same control signals. The cycle-to-cycle error of a system when trying to perform a specific task.

Resolution: the smallest increment of motion or distance that can be detected or controlled by the control system of a mechanism. The resolution of any joint is a function of encoder pulses per revolution and drive ratio, and dependent on the distance between the tool center point and the joint axis.

Robot Program: a robot communication program for IBM and compatible personal computers. Provides terminal emulation and utility functions. This program can record all of the user memory, and some of the system memory to disk files.

Maximum Speed: the compounded maximum speed of the tip of a robot moving at full extension with all joints moving simultaneously in complimentary directions. This speed is the theoretical maximum and should under no circumstances be used to estimate cycle time for a particular application. A better measure of real world speed is the standard twelve inch pick and place cycle time. For critical applications, the best indicator of achievable cycle time is a physical simulation.

Servo Controlled: controlled by a driving signal which is determined by the error between the mechanism's present position and the desired output position.

Via Point: a point through which the robot's tool should pass without stopping; via points are programmed in order to move beyond obstacles or to bring the arm into a lower inertia posture for part of the motion.

Work Envelope: a three-dimensional shape that defines the boundaries that the robot manipulator can reach; also known as reach envelope.

1. *Answer the questions:*

1) What is an articulated robot?

2) How can articulated robots range?

3) What does the articulated robot arm have?

4) What are three ways of movement?

5) Describe the function of each axis.

6) What is a continuous Path?

7) The number of independent motions in which the end effector can move, defined by the number of axes of motion of the manipulator is called …

8) What is the device for grasping or holding, attached to the free end of the last manipulator link?

9) What is payload?

10) When is nominal payload measured?

11) What is Pick and Place Cycle?

12) How is the maximum horizontal distance from the center of the robot base to the end of its wrist called?

13) What is absolute accuracy?

14) What is repeatability?

15) What does the resolution of any joint dependent on?

16) What is Robot Program?

17) What is a better measure of real world speed?

18) What is Servo Controlled controlled by?

19) What is Via Point?

20) What is a three-dimensional shape that defines the boundaries that the robot manipulator can reach?

2. Continue the sentences:

1) Articulated robots can range from simple two-jointed structures to systems with …

2) An articulated robot is one which uses rotary joints to …

3) With the ability to rotate all the joints, a majority of articulated robots have…

4) This mobility allows articulated robots to be used for tasks such as …

5) Degrees Of Freedom (DOF): the number of independent motions in which the end effector can move, defined by …

6) Nominal payload is measured at maximum speed while …

7) Reach: the maximum horizontal distance from the center of the robot base to…

8) Repeatability is the cycle-to-cycle variation of the manipulator arm when…

9) The resolution of any joint is a function of encoder pulses per revolution and drive ratio, and dependent on …

10) Robot Program: a robot communication program for IBM and …

Text 8

Articulated robot and control pendant

Linear actuator – линейный привод
fold back in – откинуться назад
gripper – манипулятор для захвата
yaw – рысканье
pitch or pivoting – шаг или поворот
robot’s work envelope – рабочая оболочка робота

altitude – высота
extend or retract – удлинять или убирать
toggle – тумблер
slider - ползунок

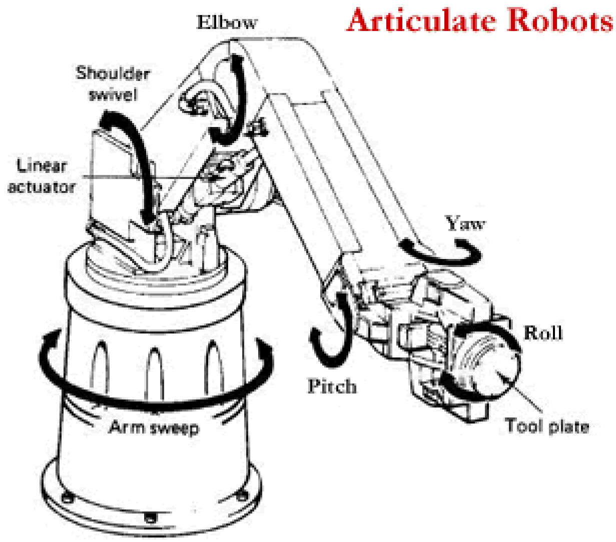


Figure 4

The articulated robot (or sometimes called jointed-arm robot) has a configuration similar to the human arm. It has two straight components joined by a joint – similar to the human forearm and upper arm joined by the elbow. The arm is connected to a base with a rotary joint similar to a shoulder. Linear actuators often control the movement of the arm to reach out or fold back in. A wrist is attached to the end of the forearm and a manipulator is attached to the wrist.

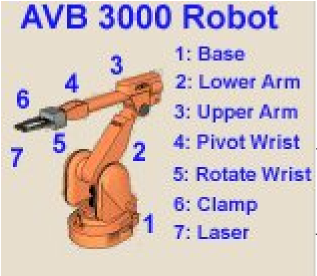
The manipulator may have many different types of grippers or tools attached to a tool plate to perform a particular task. The gripper or manipulator may be changed out to modify the type of task the robot performs.

A common definition of robot motion for articulated robots breaks the motion into two main categories:

1) Positional includes the arms and the base of the robot. The rotation of the base and rotation of the upper and lower arm define the major portion of the robot work space.

2) Orientation consists of the wrist motions which are typically three: rotation, yaw, and pitch or pivoting. Look at this illustration to see how these motions are defined.

For polar, articulated, and cylindrical robots, three degrees of freedom (DOF) are defined as positional in nature. That is, these three degrees of freedom position the wrist of the robot within the robot's work envelope. These three positioning movements are:



1) Vertical – the ability to move the wrist up and down to obtain the desired vertical altitude.

2) Radial – the ability to extend or retract the wrist from the vertical center of the robot.

3)Rotational – the ability to rotate about the base or vertical axis of the robot. In this activity, you will operate an articulated robot using a Teaching Pendant. Throughout the activity you will explore different methods for reaching the same goal. By using the Teaching Pendent, you will be able to access each of the *AVB 3000 robots' 6 different axis. Each axis has a different range and operation method. By reviewing the Robot Data Sheet, you will be able to discover how the joints react to movement and the ranges in which they operate.

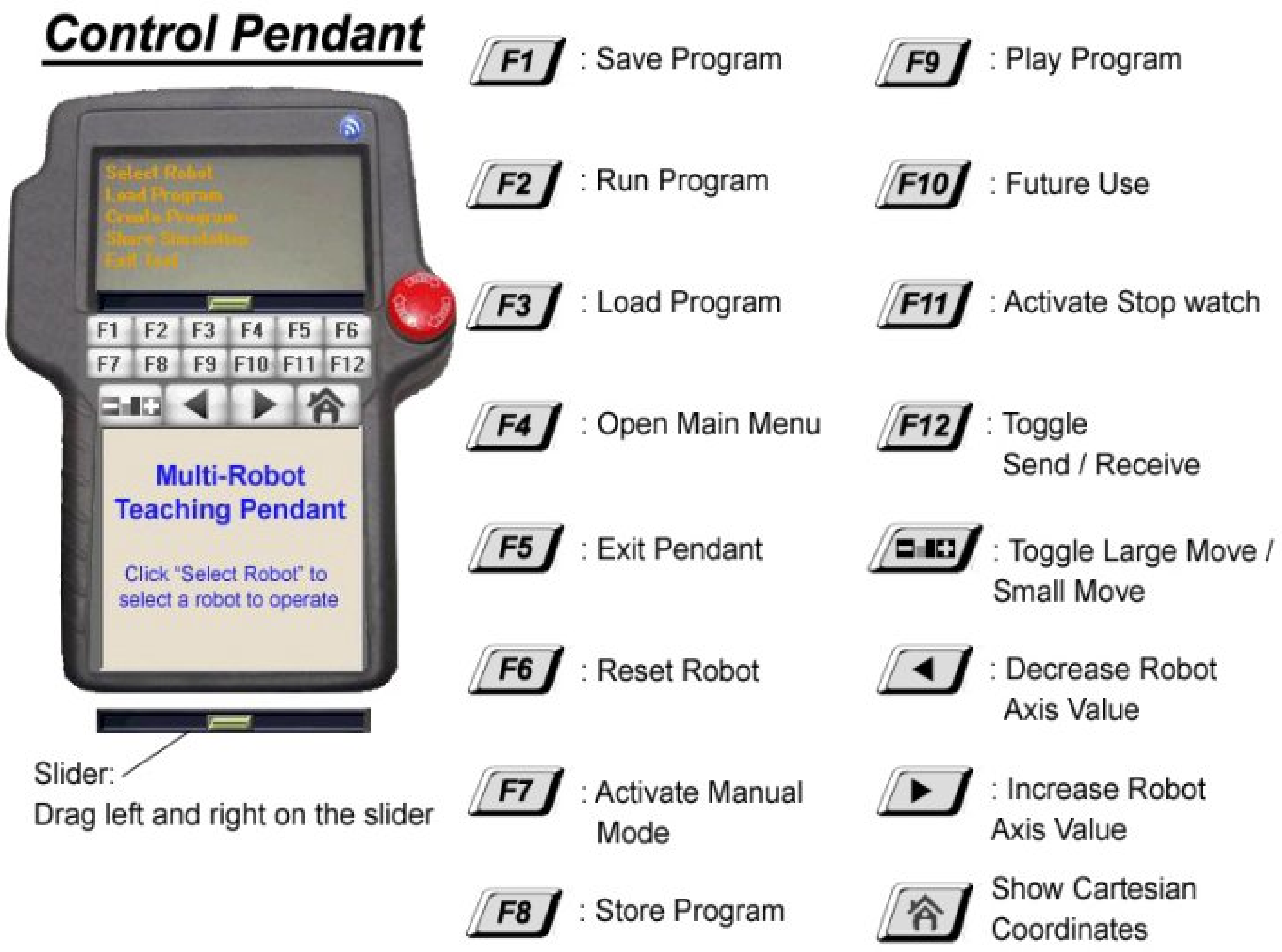


Figure 5

We have named our simulated robot Model AVB3000. This simulated robot is similar to many industrial robots, but not identical to any particular model.

Use the buttons on the teach pendant to operate the AVB 3000 robot. First select the AVB 3000 from the menu in the display area of the teach pendant. Then use these buttons for control:

1) The + and – buttons modify the step size or how much the robot moves in one step.

2) Select a part to be moved.

3) Click the > and < buttons to move forward or back or left or right or up or down depending on which robot part is moved (directions are displayed at the bottom of the teach pendant after the part is selected).

4) Click the F6 button to move the robot back to the starting position.

1. Answer the questions:

1) What configuration does the articulated robot (or sometimes called jointed-arm robot) has?

2) What are two main categories of articulated robots according to a common definition?

3) What are these three positioning movements of the wrist of the robot within the robot's work envelope?

4) How can you operate the AVB 3000 robot?

5) What button can modify the step size or how much the robot moves in one step?

6) What button can move forward or back or left or right or up or down depending on which robot part is moved?

7) What button can move the robot back to the starting position?

Text 9

Cartesian coordinate robot

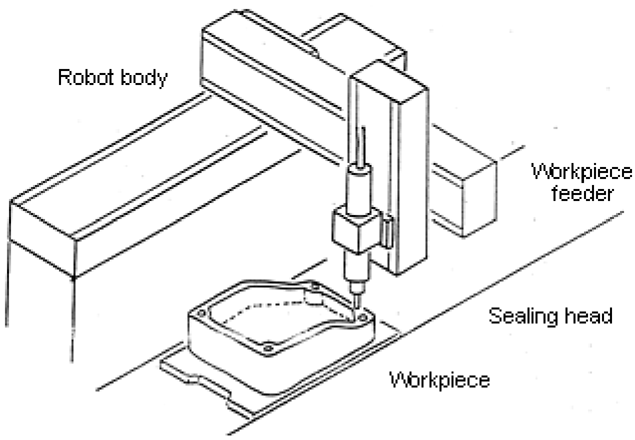


Figure 6

cartesian coordinate robot - декартово координатный робот
sliding joints – скользящие соединения

rigid structure – жесткая структура
counterpart – аналог
welding – сварка
gluing – склеивание
soldering - пайка

Typical Cartesian robots have 3 linear axes of freedom which are perpendicularly oriented at each other. As you can understand, this ensures a working envelope in a form of a rectangular box. Of course, absolutely everything has its pros and cons. The same goes for this type of robots. I'll start with the good things.

Because of their rigid structure, this type of robots usually can offer good levels of precision and repeatability. For example, a 3-axes Cartesian robot - EPSON's RP-HMSz have a repeatability +-0.01 mm for comparison - ABB's smallest 6-axis robotic arm IRB 140 has "only" +- 0.03 mm.

OK, I admit that an articulated 6-axis robotic arm is not comparable to a 3-axis Cartesian, nevertheless, the Cartesian one is better in terms of repeatability. The reason why is quite obvious - the lesser axes, the lesser joints, the lesser joints, the better precision.

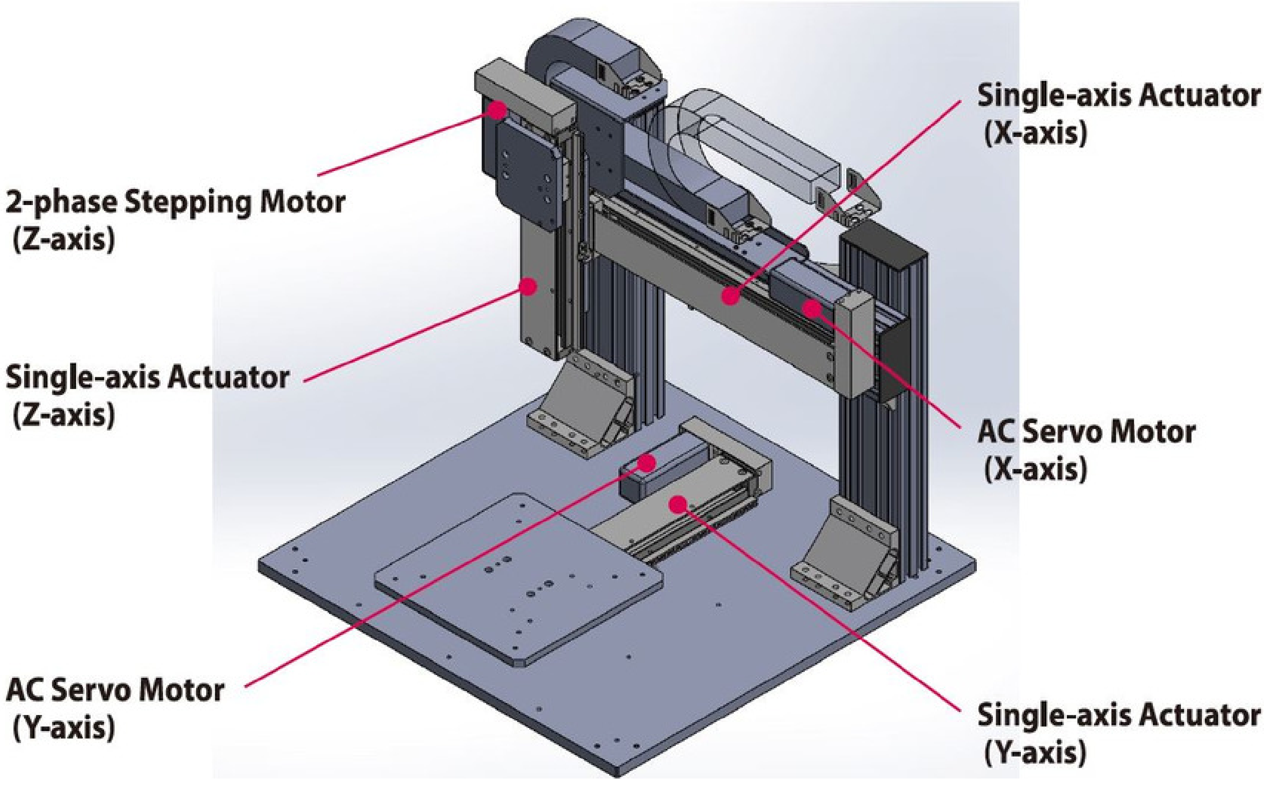


Figure 7

Theoretically, this type of robots are also easier to program. However, nowadays this argument could have lost its strength. I say so because usually robots' manufacturers have their own software for their products and all computing and control is actually done "under the hood".

As you can understand, Cartesian robots are the simplest of all stationary robots. Basically, it is even possible to build one by yourself. There are many manufacturers that supply either electric, either pneumatic linear modules - FESTO, EPSON, BOSCH are a few of them. Theoretically, you could buy components needed and assemble a Cartesian robot. This is where the programming issue would come in play. Although it is still far from easy, a Cartesian robot could be programmed "manually".

And last but not least - pricing. Because of their relative simplicity, if compared to other types of robots that could do similar tasks, Cartesian robots are ought to be cheaper than their counterparts.

So what are the cons? Well, as you can imagine their work envelope is far from ideal. Also, the possibilities of tool orientation are very limited. Of course, it is possible to have a Cartesian robot with a 4-th rotary axis of freedom at the end of the vertical linear axis. Nevertheless, it still won't be able to make movements needed for some tasks, like welding, for example. Also, its footprint can be quite large compared to other robots that could do the same task.

Taking these issues into consideration a conclusion can be drawn. A typical robot of Cartesian type can be the cheapest solution for simple pick and place operations. Also, it can be very effective for tasks where extensive tool orientation is not required or even better - if it should be avoided. For example - gluing, soldering, possibly sewing, pick and place operations etc.

1. Is there statements TRUE or FALSE?

1) Typical Cartesian robots have 3 linear axes of freedom which are parallel oriented at each other.

2) Because of their flexible structure, this type of robots usually can offer good levels of precision and repeatability.

3) OK, I admit that an articulated 6-axis robotic arm is not comparable to a 3-axis Cartesian, nevertheless, the Cartesian one is worse in terms of repeatability.

4) Cartesian robots are the most sophisticated of all stationary robots.

5) Because of their relative simplicity, if compared to other types of robots that could do similar tasks, Cartesian robots are ought to be more expensive than their counterparts.

6) it is possible to have a Cartesian robot with a 5-th rotary axis of freedom at the end of the vertical linear axis.

7) A typical robot of articulated type can be the cheapest solution for simple pick and place operations.

2. Discuss each feature and complete the table: advantages and disadvantages of Cartesian Coordinate (x,y,z) – movement base, access, height.

1) Consist of three linear axes;

2) Access is limited only at the front part;

3) Easy to describe;

4) Need wire area workplace;
5) Hard and robust structure;
6) Can be programmed in and off-line situation;
7) Axes are quite difficult to change;
8) Linear axes can make mechanical movement layoff easer

Advantages	Disadvantages

Text 10

4 Types of Collaborative Robots

hand guiding – ручное управление
designated robot zone – обозначенную зону робота
exposed motors – открытые двигатели
pinch points – точки сжатия
padded “skin” – мягкая поверхность
to dissipate force – чтобы рассеивать силу
alongside humans – вместе с людьми
fencing – ограждения
oftentimes – зачастую
offset – компенсируются
downtime – время простоя
to mitigate - снижать
in conjunction with – в сочетании с

Often times you may hear of manufacturers opting to replace their human workforce with robots in order to increase productivity. However, there are some drawbacks to doing this; robots are not good at doing everything. What if you could add robots to your operation, while keeping everything that you love about your human workforce? The answer is here: collaborative robots.

What is a collaborative robot?

Collaborative robots are designed to work alongside their human counterparts in a variety of configurations, often teaming up to accomplish tasks that neither could do on their own. Collaborative robots are defined by ISO 10218, which defines four main collaborative robot features: Safety monitored stop, speed and separation monitoring, power and force limiting, and hand guiding.

Safety Monitored Stop

This is perhaps the simplest method of collaborative robots and is used in applications when human interference with the robot is infrequent. This type of collaboration utilizes a traditional industrial robot in conjunction with safety devices such as a laser scanner that detects employee entrance into the designated robot zone. If an employee is detected entering the robot zone, the robot stops and the employee can perform any necessary work operations, and then resume the robot at the push of a button. For example, this type of collaboration is often used when a large industrial robot is needed due to loads, but a secondary operation has to be performed by an operator.

Speed and Separation Monitoring

This type of collaborative robot installation also uses traditional industrial robots, but it is more suited for environments where employees will be frequently interacting with the robot. In this type of installation, the area around the robot is constantly monitored by a vision system, which can detect employee proximity to the robot. If the employee enters the "warning" zone, the robot slows to a safe speed and if the employee enters the "stop" zone, the robot pauses until the employee has left the zone. Once the employee leaves the zone, the robot automatically resumes operation. This robot is better than safety monitored stop in instances with frequent employee interaction because the robot will automatically determine the safe running speed based on the location of the employee.

Power and Force Limiting

Power and force limiting robots are the most collaborative of the types mentioned in this article and are the only ones that can truly work alongside humans without any additional safety devices and process interruption. These robots are designed with collaboration in mind meaning they don't have any sharp corners, exposed motors, or pinch points. They have sensitive force monitoring devices, and often have a padded "skin" to dissipate force in the event of a collision. These robots work alongside humans and stop instantly if any collision is detected. This means that no vision system, laser scanners, or fencing is required when the robot is properly configured. Oftentimes the extra cost of the force limited robots is offset by the cost savings of not having to purchase and program a network of safety scanners. Currently, these force limiting robots are limited to smaller applications 35kg or less.

Hand Guiding

Hand Guiding is a collaborative feature that some robots have. It allows a programmer to "teach" robot paths and positions simply by moving the robot with their hand to the desired position. This is especially useful in instances when the robot needs to be reprogrammed on the fly. The new positions can be taught quickly which limits downtime. It should be noted that if the robot is not a force limited robot, the proper safety guarding and logic should still be in place for regular operations.

Risk Assessment

With all collaborative robots, a risk assessment of the application should be done to determine all possible risks and proper devices and procedures to mitigate the risk should be implemented. All collaborative robot applications should follow ISO 10218. However, not all processes are applicable to collaborative robots, which is why a risk assessment needs to be done by a qualified person for each application.

1. Answer the questions:

1) Why do manufacturers opt to replace their human workforce with robots?
2) What is main drawback of robots?
3) What are collaborative robots designed to?
4) What standard defines collaborative robots?
5) What are four main collaborative robot features?
6) What is the simplest method of collaborative robots used in applications when human interference with the robot is infrequent?
7) What is the function of a laser scanner in “Safety Monitored Stop” features?
8) What happens if an employee is detected entering the robot zone?
9) Which robot will automatically determine the safe running speed based on the location of the employee?
10) Which robots can truly work alongside humans without any additional safety devices and process interruption?
11) How is the extra cost of the force limited robots offset by?
12) What does Hand Guiding allow to do?
13) Should it be noted that if the robot is not a force limited robot, the proper safety guarding and logic?
14) What components should still be in place for regular operations even if the robot is not a force limited robot?
15) Why should a risk assessment of the application be done with all collaborative robots?

2. Complete the gaps in the text:

Cobot

released	control	automotive	invented	humans	cobot	roles

A cobot or co-robot (from collaborative robot) is a robot intended to physically interact with ____ (1) in a shared workspace. This is in contrast with other robots, designed to operate autonomously or with limited guidance, which is what most industrial robots were up until the decade of the 2010s.

Cobots were ____ (2) in 1996 by J. Edward Colgate and Michael Peshkin, professors at Northwestern University. A 1997 US patent filing describes cobots as an apparatus and method for direct physical interaction between a person and a general purpose manipulator controlled by a computer.

Cobots resulted from a 1994 General Motors initiative led by Prasad Akella of the GM Robotics Center and a 1995 General Motors Foundation research grant intended to find a way to make robots or robot-like equipment safe enough to team with people. The first cobots assured human safety by having no internal source of motive power. Instead, motive power was provided by the human worker. The cobot's function was to allow computer ___ (3) of motion, by redirecting or steering a payload, in a cooperative way with the human worker. Later cobots provided limited amounts of motive power as well.

The General Motors team used the term Intelligent Assist Device (IAD) as an alternative to cobot, especially in the context of industrial material handling and ____ (4) assembly operations. A draft safety standard for Intelligent Assist Devices was published in 2002. An updated safety standard was published in 2016.

Cobotics released several ____ (5) models in 2002.

Universal Robots released its first cobot, the UR5, in 2008. In 2012 the UR10 cobot was____ (6), and later a table top cobot, UR3, in 2015. KUKA's LBR iiwa was the result of a long collaboration with the German Aerospace Centerinstitute. Rethink Robotics released an industrial cobot, Baxter, in 2012.

FANUC - the world's largest producer of industrial robots - released its first collaborative robot in 2015 - the FANUC CR-35iA with a heavy 35kg payload. Since that time FANUC has released a smaller line of collaborative robots including the FANUC CR-4iA, CR-7iA and the CR-7/L long arm version.

Cobots can have many ____ (7) — from autonomous robots capable of working together with humans in an office environment that can ask you for help, to industrial robots having their protective guards removed as they can react to a human presence under EN ISO 10218 or RSA BSR/T15.1.

Read the scheme and try to remember information. Cover it. Look at the dates and remind events:

1920 –	2001-2005 –	2012 – 2016 –
1954 –	2005 –	2014 – 2015 –
1960 – 2000 –	2012 –	2016 -

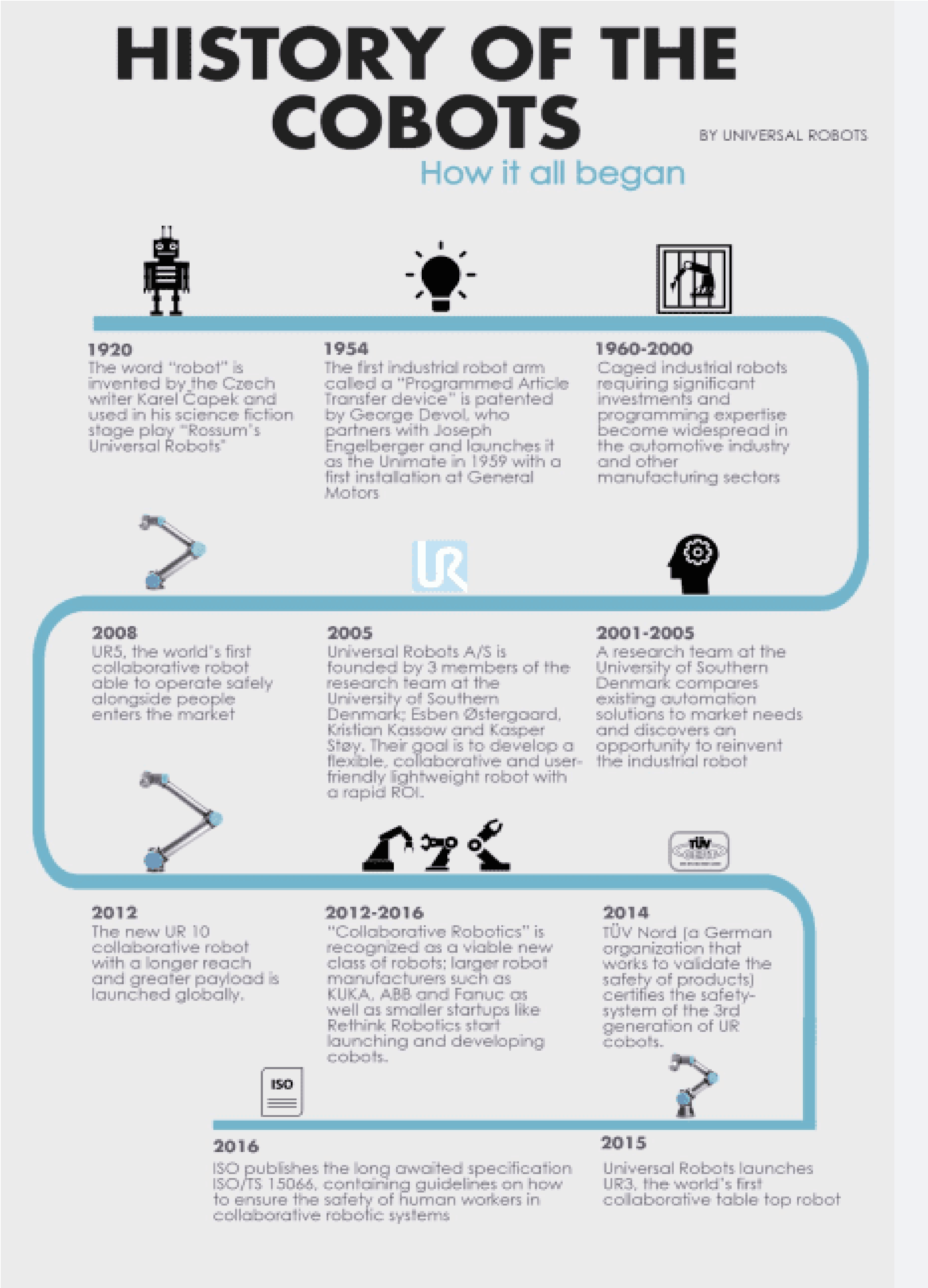


Figure 8

Text 11

Delta robot

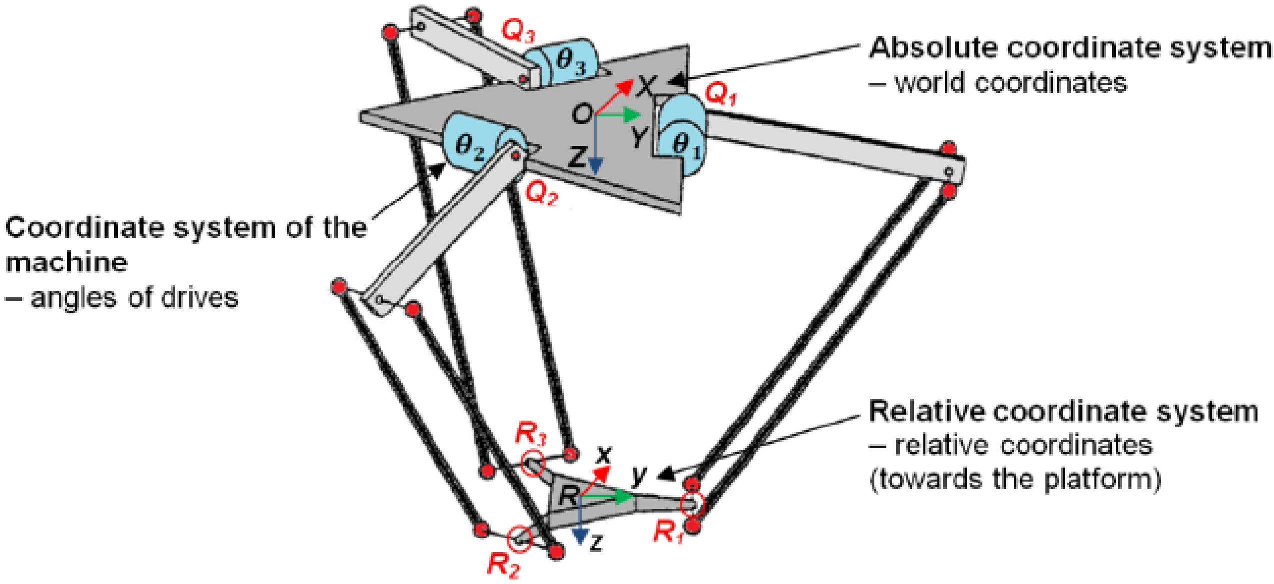


Figure 9

École Polytechnique Fédérale de Lausanne – политехническая школа Лозанны
for heavier payloads – для более тяжелых нагрузок
end-effector – конечный эффектор
spatial generalization - пространственное обобщение
four-bar linkage - четырехбалочная связь
workspace – рабочая зона
stiffness – жесткость, неподвижность
translation – сдвиг, перемещение
flexure-hinges joints – сочленения, сгибающиеся с помощью шарниров
the motors drive linear actuators – двигатели приводят в действие линейные приводы
arm - рычаг
rotary actuators - поворотные приводы
vertical linear actuators – вертикальные линейные приводы
novel design – новая конструкция
haptic controllers – тактические контроллеры

A delta robot is a type of parallel robot. It consists of three arms connected to universal joints at the base. The key design feature is the use of parallelograms in the arms, which maintains the orientation of the end effector. By contrast, a Stewart platform can change the orientation of its end effector.

Delta robots have popular usage in picking and packaging in factories because they can be quite fast, some executing up to 300 picks per minute

The delta robot (a parallel arm robot) was invented in the early 1980s by a research team led by professor Reymond Clavel at the École Polytechnique Fédérale de Lausanne (EPFL, Switzerland). The purpose of this new type of robot was to manipulate light and small objects at a very high speed, an industrial need at that time. In 1987, the Swiss company Demaurex purchased a license for the delta robot and started the production of delta robots for the packaging industry. In 1991 Reymond Clavel presented his doctoral thesis 'Conception d'un robot parallèle rapide à 4 degrés de liberté', and received the golden robot award in 1999 for his work and development of the delta robot. Also in 1999, ABB Flexible Automationstarted selling its delta robot, the FlexPicker. By the end of 1999 delta robots were also sold by Sigpack Systems.

In 2009, FANUC released the newest version of the Delta robot, the FANUC M-1iA Robot, and would later release variations of this Delta robot for heavier payloads. FANUC released the M-3iA in 2010 for heavier payloads, and most recently the FANUC M-2iA Robot for medium-sized payloads in 2012.

The delta robot is a parallel robot, i.e. it consists of multiple kinematic chains connecting the base with the end-effector. The robot can also be seen as a spatial generalization of a four-bar linkage.

The key concept of the delta robot is the use of parallelograms which restrict the movement of the end platform to pure translation, i.e. only movement in the X, Y or Z direction with no rotation.

The robot's base is mounted above the workspace and all the actuators are located on it. From the base, three middle jointed arms extend. The ends of these arms are connected to a small triangular platform. Actuation of the input links will move the triangular platform along the X, Y or Z direction. Actuation can be done with linear or rotational actuators, with or without reductions (direct drive).

Since the actuators are all located in the base, the arms can be made of a light composite material. As a result of this, the moving parts of the delta robot have a small inertia. This allows for very high speed and high accelerations. Having all the arms connected together to the end-effector increases the robot stiffness, but reduces its working volume.

The version developed by Reymond Clavel has four degrees of freedom: three translations and one rotation. In this case a fourth leg extends from the base to the middle of the triangular platform giving to the end effector a fourth, rotational degree of freedom around the vertical axis.

Currently other versions of the delta robot have been developed:

1) Delta with 6 degrees of freedom: developed by the company Fanuc, on which a serial kinematic with 3 rotational degrees of freedom is placed on the end effector.

2) Delta with 4 degrees of freedom: developed by the company Adept, which has 4 parallelogram directly connected to the end-platform instead of having a fourth leg coming in the middle of the end-effector.

3) Pocket Delta: developed by the Swiss company Astral SA, a 3-axis version of the Delta Robot adapted for flexible part feeding systems and other high-speed, high-precision applications.

4) Delta Direct Drive: a 3 degrees of freedom Delta Robot has the motor directly connected to the arms. Accelerations can be very high, from 30 up to 100 g.

5) Delta Cube: developed by the EPFL university laboratory LSRO, a delta robot built in a monolithic design, having flexure-hinges joints. This robot is adapted for ultra-high-precision applications.

6) Several "*linear delta*" arrangements have been developed where the motors drive linear actuators rather than rotating an arm. Such linear delta arrangements can have much larger working volumes than rotational delta arrangements.

The majority of delta robots use rotary actuators. Vertical linear actuators have recently been used (using a linear delta design) to produce a novel design of 3D printer. These offer advantages over conventional leads crew-based 3D printers of quicker access to a larger build volume for a comparable investment in hardware.
Industries that take advantage of the high speed of delta robots are the packaging industry, medical and pharmaceutical industry. For its stiffness it is also used for surgery. Other applications include high precision assembly operations in a clean room for electronic components. The structure of a delta robot can also be used to create haptic controllers. More recently, the technology has been adapted to 3D printers. These printers can be built for about a thousand dollars and compete well with the traditional Cartesian printers from the RepRap project.

1. Answer the questions:

1) What parts does delta robot consist of?

2) What is the key design feature of delta robot?

3) Why do delta robots have popular usage in picking and packaging in factories?

4) Who invented the delta robot?

5) Where was the first industrial application of delta robots?

6) What contribution did Reymond Clavel make to the development of the delta robots?

7) What kinds of robots did FANUC produce?

8) What does the term "parallel robot" mean?

9) What is the key concept of the delta robot?

10) How can actuation be done?

11) Why can the arms be made of a light composite material?

12) Describe the version developed by Reymond Clavel.

13) What type of robot:

a) is adapted for ultra-high-precision applications?

b) has 4 parallelogram directly connected to the end-platform instead of having a fourth leg coming in the middle of the end-effector?

c) has been developed where the motors drive linear actuators rather than rotating an arm?

d) has the motor directly connected to the arms?

e) developed by the company Fanuc, on which a serial kinematic with 3 rotational degrees of freedom is placed on the end effector?

f) developed by the Swiss company Astral SA, a 3-axis version of the Delta Robot adapted for flexible part feeding systems and other high-speed, high-precision applications?

14) What type of actuators do the majority of delta robots use?

15) What advantages do vertical linear actuators have over conventional leads crew-based 3D printers?

16) Where are delta robots applied?

2. Is there statements TRUE or FALSE?

1) The key design feature is the use of spheres in the arms, which maintains the orientation of the end effector.

2) Delta robots have popular usage in picking and packaging in factories because they can be quite fast, some executing up to 500 picks per minute.

3) The purpose of delta robot was to manipulate heavy and big objects at a very high speed, an industrial need at that time.

4) In 1995, ABB Flexible Automation started selling its delta robot, the FlexPicker.

5) FANUC released the M-3iA in 2010 for heavier payloads, and most recently the FANUC M-2iA Robot for light-sized payloads in 2012.

6) The robot's base is mounted below the workspace and all the actuators are located on it.

7) Having all the arms connected together to the end-effector reduces the robot stiffness, but increases its working volume.

8) *Delta with 6 degrees of freedom*: developed by the company Fanuc, on which a serial kinematic with 6 rotational degrees of freedom is placed on the end effector.

9) *Delta Direct Drive*: a 3 degrees of freedom Delta Robot has the motor directly connected to the arms. Accelerations can be very high, from 70 up to 100 g.

10) Several "*linear delta*" arrangements have been developed where the motors rotate an arm.

Text 12

Drones

life-critical systems – жизненно-важные системы
sturdy materials – прочные материалы
robustly tested electronic control systems - надежные электронные системы управления
layout – макет
cockpit – кабина пилота
feature sets – набор функций

battery elimination circuitry – цепь, исключающая батарею
harbors – содержит
costlier switching BECs – более быстрая коммутация
single-board computers (SBC) - одноплатные компьютеры
RPM [revolutions per minute] - оборо́т в мину́ту
payload actuators - приводы полезной нагрузки
LEDs – светодиоды
speakers – динамики
designed from scratch - созданные с нуля
open-loop architecture - архитектура с открытым контуром
closed-loop architecture - архитектура с замкнутым контуром
without incorporating – без учета
tailwind - попутный ветер
altitude – высота
firmware – прошивка

Figure 10

An unmanned aerial vehicle (UAV), commonly known as *a drone* is an aircraft without a human pilot aboard. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers.

Manned and unmanned aircraft of the same type generally have recognizably similar physical components. The main exceptions are the *cockpit* and *environmental control system* *or* *life support systems*. Some UAVs carry payloads (such as a camera) that weigh considerably less than an adult human, and as a result can be considerably smaller. Though they carry heavy payloads, weaponized military UAVs are lighter than their manned counterparts with comparable armaments.

Small civilian UAVs have no *life-critical systems*, and can thus be built out of lighter but less sturdy materials and shapes, and can use less robustly tested electronic control systems. For small UAVs, the *quadcopter* design has become popular, though this layout is rarely used for manned aircraft. Miniaturization means that less-powerful propulsion technologies can be used that are not feasible for manned aircraft, such as small electric motors and batteries.

Control systems for UAVs are often different than manned craft. For remote human control, a camera and video link almost always replace the cockpit windows; radio-transmitted digital commands replace physical cockpit controls. Autopilot software is used on both manned and unmanned aircraft, with varying feature sets.

The primary difference for planes is the absence of the cockpit area and its windows. Tailless quadcopters are a common form factor for rotary wing UAVs while tailed mono- and bi-copters are common for manned platforms.

Small UAVs mostly use lithium-polymer batteries (Li-Po), while larger vehicles rely on conventional airplane engines.

Battery elimination circuitry (BEC) is used to centralize power distribution and often harbors a microcontroller unit (MCU). Costlier switching BECs diminish heating on the platform.

UAV computing capability followed the advances of computing technology, beginning with analog controls and evolving into microcontrollers, then system-on-a-chip (SOC) and single-board computers (SBC).

System hardware for small UAVs is often called the Flight Controller (FC), Flight Controller Board (FCB) or Autopilot.

Position and movement sensors give information about the aircraft state. Exteroceptive sensors deal with external information like distance measurements, while exproprioceptive ones correlate internal and external states.

Non-cooperative sensors are able to detect targets autonomously so they are used for separation assurance and collision avoidance.

Degrees of freedom (DOF) refer to both the amount and quality of sensors on-board: 6 DOF implies 3-axis gyroscopes and accelerometers (a typical inertial measurement unit – IMU), 9 DOF refers to an IMU plus a compass, 10 DOF adds a barometer and 11 DOF usually adds a GPS receiver.

UAV actuators include digital electronic speed controllers (which control the RPM of the motors) linked to motors/engine sand propellers, servomotors (for planes and helicopters mostly), weapons, payload actuators, LEDs and speakers.

UAV software called the flight stack or autopilot. UAVs are real-time systems that require rapid response to changing sensor data. Examples include Raspberry

Pis,Beagleboards, etc. shielded with NavIO, PXFMini, etc. or designed from scratch such as Nuttx, preemptive-RT Linux, Xenomai, Orocos-Robot Operating System or DDS-ROS 2.0.

Flight stack overview

Layer	Requirement	Operations	Example
Firmware	Time-critical	From machine code to processor execution, memory access…	ArduCopter-v1.px4
Middleware	Time-critical	Flight control, navigation, radio management...	Cleanflight, ArduPilot
Operating system	Computer-intensive	Optic flow, obstacle avoidance, SLAM, decision-making...	ROS, Nuttx, Linux distributions, Microsoft IOT

UAVs employ open-loop, closed-loop or hybrid control architectures:

1) Open loop—This type provides a positive control signal (faster, slower, left, right, up, down) without incorporating feedback from sensor data.

2) Closed loop – This type incorporates sensor feedback to adjust behavior (reduce speed to reflect tailwind, move to altitude 300 feet). The PID controller is common. Sometimes, feed forward is employed, transferring the need to close the loop further

1. Answer the questions:

1) What components does an unmanned aircraft system (UAS) include?

2) How may the flight of UAVs operate?

3) What are the main exceptions of manned and unmanned aircrafts?

4) Why are weaponized military UAVs lighter than their manned counterparts?

5) Why can small civilian UAVs be built out of lighter but less sturdy materials and shapes?

6) What does miniaturization mean?

7) What is the primary difference for planes?

8) What source of energy do small UAVs mostly use?

9) What is used to centralize power distribution?

10) What diminish heating on the platform?

11) How system hardware for small UAVs is often called?

12) Describe all types of sensors (position and movement sensors, exteroceptive sensors, expproprioceptive sensors, non-cooperative sensors).

13) What do degrees of freedom (DOF) refer to?

14) What do UAV actuators include?

15) What do UAVs real-time systems (UAVs) require?

16) What type of architectures do UAVs employ?

17) Which type of architecture provides a positive control signal (faster, slower, left, right, up, down) without incorporating feedback from sensor data?

18) Which type of architecture incorporates sensor feedback to adjust behavior (reduce speed to reflect tailwind, move to altitude 300 feet)?

2. Discuss the information about drones. Does each fact express the pros or cons of UAVs or drones?

1) Drones greatly reduce putting military personnel in harm’s way or in combat.

2) Drones cannot capture surrendering military personnel, abandoned hardware, or military bases.

3) Drones are significantly cheaper to purchase, fuel, and maintain than regular airplanes.

4) Drone warfare often causes collateral damages in civilian lives and property, as well as traditional warfare too.

5) Without a human pilot, drones can stay in operation for significantly longer hours of operation without fatigue.

6) By making drone warfare very similar to video games, drone warfare makes combat too easy by diminishing ethical decisions.

7) Drones could be exploited for spying purposes which would infringe on privacy rights.

8) Drones are able to fly under harsh conditions without risking life.

9) Battery power could be limited.

10) Camera footage is not as reliable as the naked eye.

Text 13

Gantry robots

mounting flangle - крепежный фланец
distinctive structure - отличительная структура
cartesian coordinate robot - декартово координатный робот
the carriage on the y axis - каретка на оси
aforementioned – вышеупомянутый
typically labeled – типично обозначается
the horizontal plane - горизонтальная плоскость
envelope – кожух, футляр, оболочка
cartesian type – декартовый тип
interfere – мешать
prominent use – частое использование
pick and place tasks - выбор и размещение задач
sit above – располагаться над
articulated arm robot – шарнирный робот

products handled from above - продукты, обработанные сверху
grippers of various types – захваты различных типов
be bolted - быть прикреплены болтами
grasping the parts – захват деталей
position accuracy - точность позиции
milling and drawing machines – фрезерные и чертежные машины

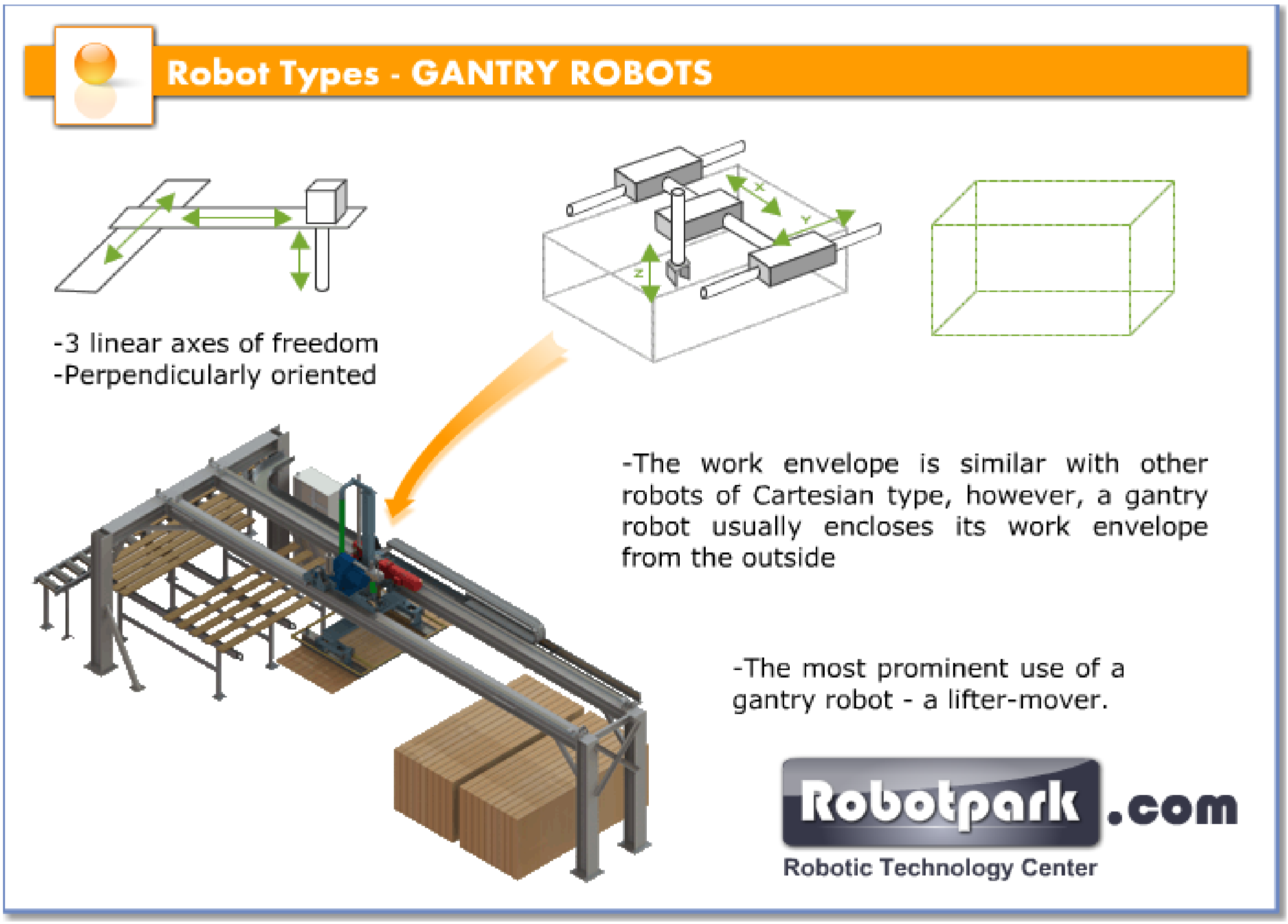


Figure 11

In many cases gantry robots are not being explained separately of other Cartesian type robots. Gantry robots should be discussed separately because of their distinctive structure and their possible applications. Cartesian coordinate robots with the horizontal member supported at both ends are sometimes called Gantry Robots. They are often quite large.

Movement along the x axis takes place between two beams which are directed in the x direction. The carriage on the y axis can move along it between aforementioned x axis beams. The tool can be lowered down from the carriage, thus forming the z axis movement.

In a gantry robot, each of these motions are arranged to be perpendicular to each other and are typically labeled X, Y, and Z. X and Y are located in the horizontal plane and Z is vertical. Think of X and Y was the width and length of a box and Z as the height of the box. The interior of this box is referred to as the working envelope of the gantry robot. A gantry robot can move things anywhere within this envelope or perform some operation on an item within the envelope.

The work envelope is similar with other robots of Cartesian type; however, a gantry robot usually encloses its work envelope from the outside. The only part of the robot that interferes with its work space is its z axis and the tool.

As you can see this robot stands firmly on four "legs". If those legs are strong enough, the robot can lift very heavy weights. This is the most prominent use of a gantry robot - a lifter-mover. So, Gantry robots can be used for pick and place tasks that could include packaging, assembly and others.

Gantry Robots excel in situation where area, speed and flexibility are required. Because the Gantry Robot sits above the working area and does not take additional space solutions are relatively compact. The portal frame is expandable in all dimensions allowing the Gantry Robots to access any required locations. Direct fast, point to point movements. Unlike an articulated arm robot the gantry movements are straight not spherical. Products handled from above evenly distributed floor loading at the legs of the Portal frame of the Gantry Robot. Single gantry robot can handle multiple lines to palletize move or store.

A typical application for a gantry robot is the assembly of a device. A gantry robot that performs this action is also referred to as a *pick and place robot*. Components required for the device are somehow brought into the working envelope of the gantry robot, and the gantry robot picks up each component and attaches or places it on the device being assembled. The device being assembled must also be within the working envelope of the gantry robot. Grippers of various types can be bolted to the end of the Z direction motion to assist in grasping the parts. Rotating motions can also be added to both the Z direction motion and the working envelope to allow for greater part manipulation.

Another typical application of a gantry robot is to perform some type of action on a part. The part must be placed within the working envelope, and the gantry robot can be programmed to weld, drill holes, or perform various other operations on the part. Rotary motions and appropriate tools are added to the gantry robot to allow it to perform its required function.

Gantry robots have several advantages over the more popular varieties of robots. Gantry robots can be made very large, filling an entire room if necessary. Gantry robots typically have much better position accuracy than their competitors.
Position accuracy refers to how close the robot can place a part to the instructed location. Gantry robots place parts exactly where programmed. This is why gantry robots are usually used for pick and place applications. Gantry robots are easier to program with respect to motion than are other robots. If the part needs to be moved from point (3,6,9) to point (4,2,8), this is simply a move of 1 unit in the X direction, -4 units in the Y direction, and -1 unit in the Z direction.

Gantry robots also have a disadvantage in that they are stationary. Everything needs to be brought into the working envelope and removed from the working envelope when completed. A gantry robot cannot go to the part; the part must come to the gantry robot.

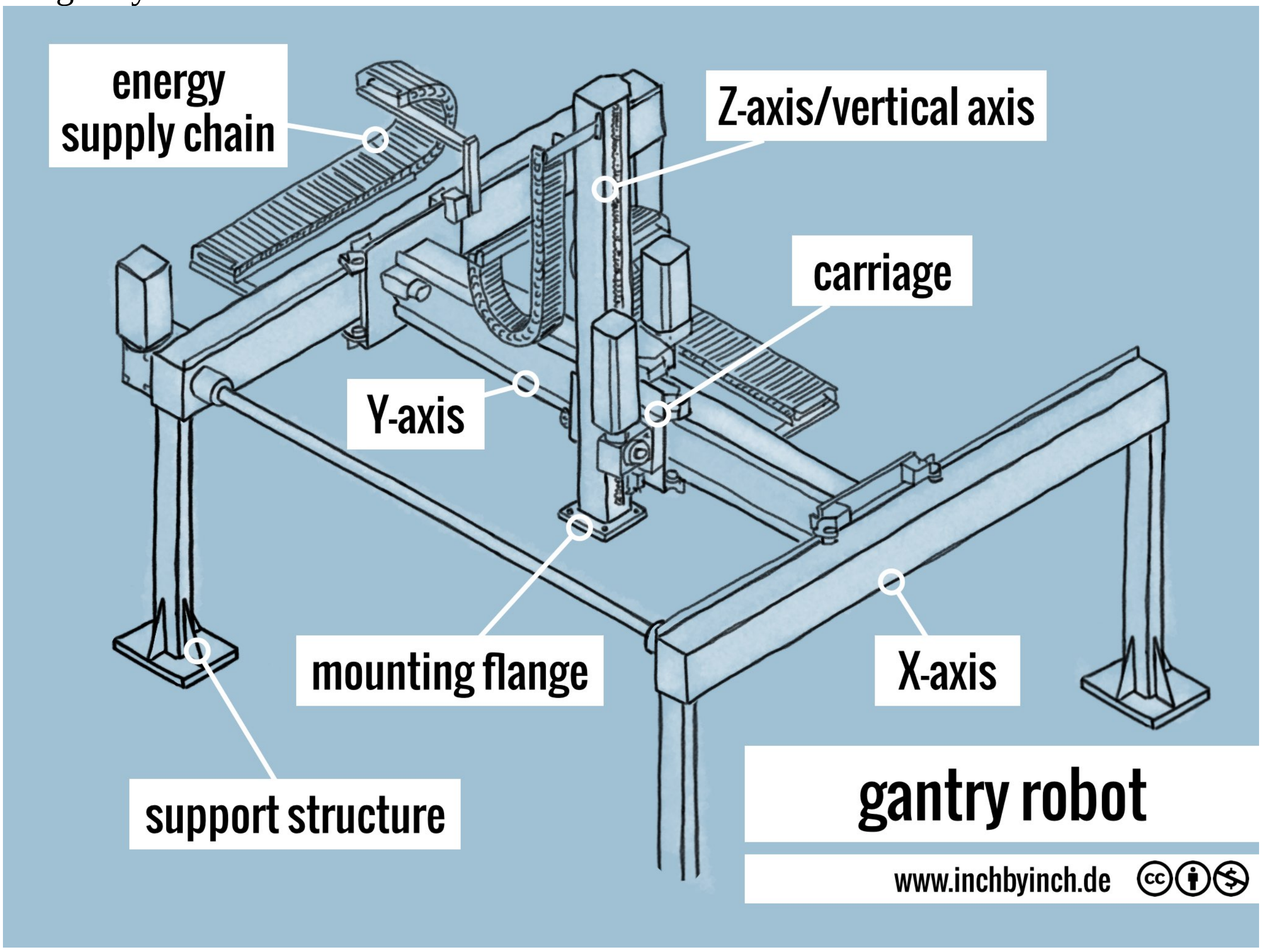


Figure 12

There is one more interesting application for a gantry robot. It can be used as a platform for other robots. For example, a 6-axes robotic arm can be mounted upside-down as a tool on a gantry robot's Z axis. A popular application for this type of robot is a computer numerical control machine (CNC machine)**.** The simplest application is used in milling and drawing machines where a pen or router translates across an x-y plane while a tool is raised and lowered onto a surface to create a precise design.

1. Answer the questions:

1) Why should Gantry robots be discussed separately?

2) What kind of robots is called Gantry Robots?

3) How does movement along the x axis take place between two beams?

4) How does each of these motions in a gantry robot occur?

5) What is the difference of the work envelope from other robots of Cartesian type?

6) What is the most prominent use of a gantry robot?

7) Why goes Gantry Robots excel in situation where area, speed and flexibility are required?

8) How does a typical application for a gantry robot (the assembly of a device) happen?

9) How does a gantry robot perform some type of action on a part?

10) What advantages do Gantry robots have over the more popular varieties of robots?

11) What disadvantage do Gantry robots have?

12) What one more interesting application does a gantry robot have?

2. Is there statements TRUE or FALSE?

1) Cartesian coordinate robots with the vertical member supported at both ends are sometimes called Gantry Robots.

2) The carriage on the x axis can move along it between aforementioned y axis beams.

3) A gantry robot can move things anywhere outside this envelope or perform some operation on an item within the envelope.

4) A gantry robot stands firmly on six "legs".

5) Unlike an articulated arm robot the gantry movements are spherical not straight.

6) Components required for the device are somehow brought into the carriage of the gantry robot, and the gantry robot picks up each component and attaches or places it on the device being assembled.

7) Stationary motions and appropriate tools are added to the gantry robot to allow it to perform its required function.

8) If the part needs to be moved from point (1,3,5) to point (4,2,8), this is simply a move of 1 unit in the X direction, -4 units in the Y direction, and -1 unit in the Z direction.

9) A gantry robot can go to the part.

10) The simplest application is used in welding and drawing machines where a pen or router translates across an x-y plane while a tool is raised and lowered onto a surface to create a precise design.

Text 14

Mobile robots

locomotion – передвижение
gripperassembly – сборщик

A mobile robot is an automatic machine that is capable of locomotion. Mobile robots have capability to move around in their environment and are not fixed to one physical location. Mobile robots can be "autonomous" (AMR - autonomous mobile robot) which means they are capable of navigating an uncontrolled environment without the need for physical or electro-mechanical guidance devices. Alternatively, mobile robots can rely on guidance devices that allow them to travel a pre-defined navigation route in relatively controlled space (AGV - autonomous guided vehicle). By contrast, industrial robots are usually more-or-less stationary, consisting of a jointed arm (multi-linked manipulator) and gripperassembly (or end effector), attached to a fixed surface.

Mobile robots have become more commonplace in commercial and industrial settings. Hospitals have been using autonomous mobile robots to move materials for many years. Warehouses have installed mobile robotic systems to efficiently move materials from stocking shelves to order fulfillment zones. Mobile robots are also a major focus of current research and almost every major university has one or more labs that focus on mobile robot research. Mobile robots are also found in industrial, military and security settings. Domestic robots are consumer products, including entertainment robots and those that perform certain household tasks such as vacuuming or gardening.

The components of a mobile robot are a controller, control software, sensors and actuators. The controller is generally a microprocessor, embedded microcontroller or a personal computer (PC). Mobile control software can be either assembly level language or high-level languages such as C, C++, Pascal, Fortran or special real-time software. The sensors used are dependent upon the requirements of the robot. The requirements could be dead reckoning, tactile and proximity sensing, triangulation ranging, collision avoidance, position location and other specific applications.

1. Answer the questions:

1) What is a mobile robot?
2) What does it mean "autonomous" mobile robot?
3) What do guidance devices allow to mobile robots?
4) What do industrial robots consist of?
5) Where do mobile robots apply?
6) What are the components of a mobile robot?
7) What is the controller?
8) What kind of mobile control software is used in mobile robots?
9) What are the sensors used dependent upon?
10) What type of the requirements could be in mobile robots?

Text 15

SCARA

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

In 1981, Sankyo Seiki, Pentel and NEC presented a completely new concept for assembly robots. The robot was developed under the guidance of Hiroshi Makino, a professor at the University of Yamanashi. The robot was called Selective

Compliance Assembly Robot Arm, SCARA. Its arm was rigid in the Z-axis and pliable in the XY-axes, which allowed it to adapt to holes in the XY-axes.

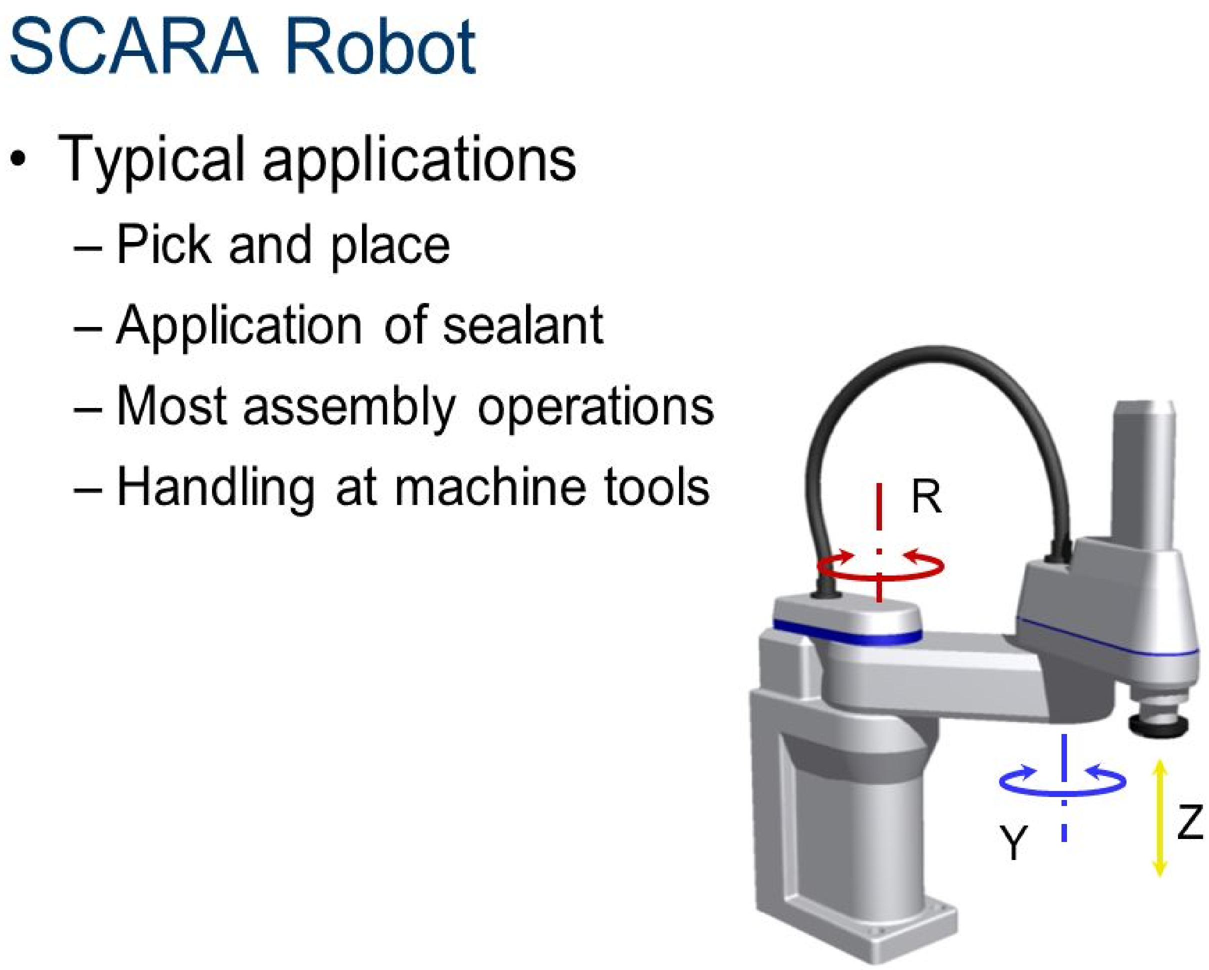


Figure 13

By virtue of the SCARA's parallel-axis joint layout, the arm is slightly compliant in the X-Y direction but rigid in the 'Z' direction, hence the term: Selective Compliant. This is advantageous for many types of assembly operations, i.e., inserting a round pin in a round hole without binding.

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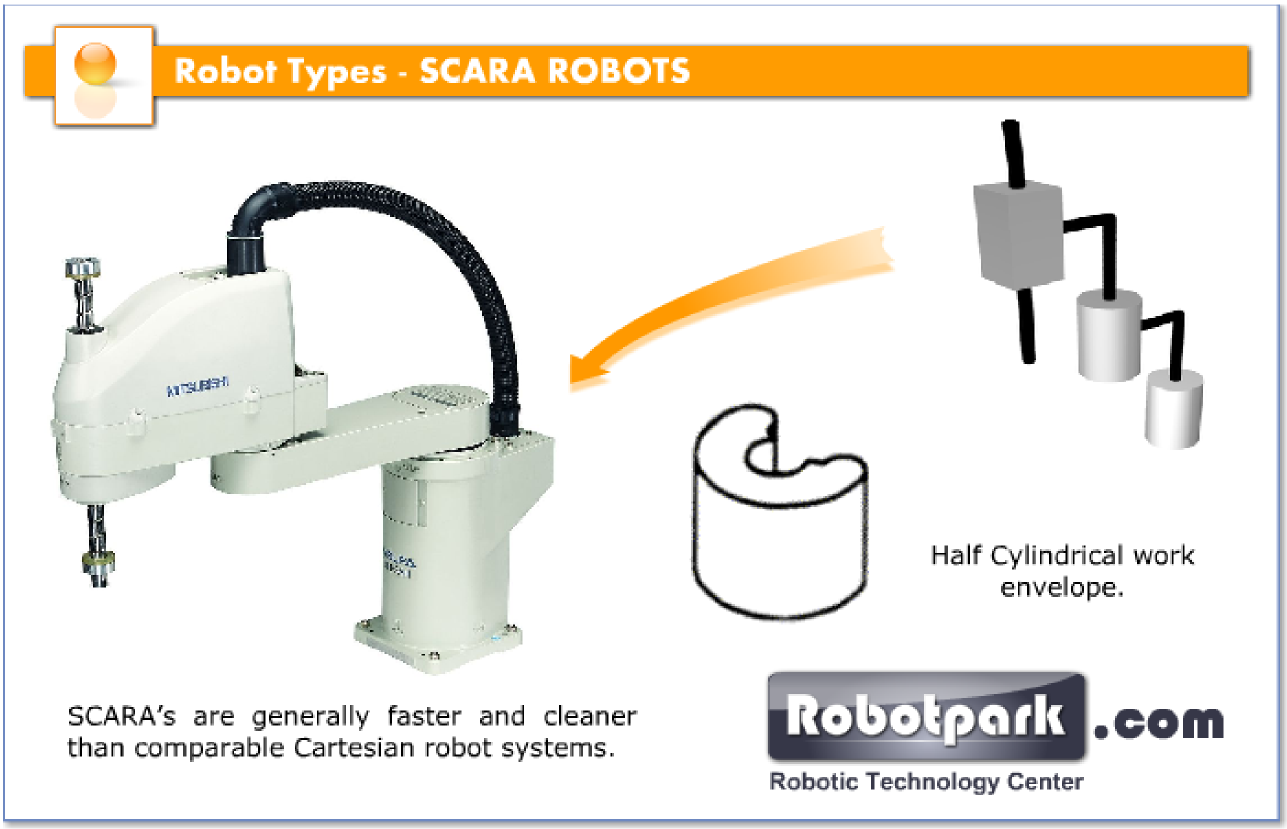

Figure 14

The second attribute of the SCARA is the jointed two-link arm layout similar to our human arms, hence the often-used term, Articulated. This feature allows the arm to extend into confined areas and then retract or "fold up" out of the way. This is advantageous for transferring parts from one cell to another or for loading/ unloading process stations that are enclosed.

SCARAs are generally faster and cleaner than comparable Cartesian robot systems. Their single pedestal mount requires a small footprint and provides an easy, unhindered form of mounting. On the other hand, SCARAs can be more expensive than comparable Cartesian systems and the controlling software requires inverse kinematics for linear interpolated moves. This software typically comes with the SCARA though and is usually transparent to the end-user.

Most SCARA robots are based on serial architectures, which mean that the first motor should carry all other motors. There also exists a so-called double-arm SCARA robot architecture, in which two of the motors are fixed at the base. The first such robot was commercialized by Mitsubishi Electric. Another example of a dual-arm SCARA robot is Mecademic's DexTAR educational robot.

1. Answer the questions:

1) What does The SCARA acronym stand for?
2) Who presented a completely new concept for assembly robots in 1981?
3) What is the main working principle of SCARA robot?
4) What is the second attribute of the SCARA?
5) What are advantages and disadvantages of SCARA?
6) What are most SCARA robots based on?

Final test

1. Translate one of the texts

What Types of Mobile Robots are there?

1) Land-based wheeled robot
2) Land-based tracked robot
3) Land-based legged robot
4) Air-based: plane, helicopter, blimp
5) Water-based; boat, submarine
6) Misc. and combination robot
7) Stationary robot (arm, manipulator etc.)

Wheels

tabletop robot – настольный робот
a caster -
skid steering – рулевое управление
rack and pinion steering - рулевое управление с рулевым механизмом
drive motors – приводной двигатель
reduce slip – уменьшать скольжение
Omni-directional wheels – всенаправленные колеса
common misconception – распространенное заблуждение
can all be custom to your needs - могут быть индивидуальными для ваших нужд
traction (slip) – тяга (скольжение)

Wheels are by far the most popular method of providing robot mobility and are used to propel many different sized robots and robotic platforms. Wheels can be just about any size, from fractions of an inch to 10 to 12 inches. Tabletop robots tend to have the smallest wheels, usually less than 2 inches in diameter. Robots can have just about any number of wheels, although 3 and 4 are the most common. Normally a three wheeled robot uses two wheels and a caster at one end. More complex two wheeled robots use gyroscopic stabilization. It is rare that a wheeled robot use anything but skid steering (like that of a tank). Rack and pinion steering such as that found on a car requires too many parts and its complexity and cost outweigh most of its advantages.

Four and six wheeled robots have the advantage of using multiple drive motors (one connected to each wheel) which reduces slip. Omni-directional wheels, mounted properly, can give the robot significant mobility advantages. A common misconception about building a wheeled robot is that large, low-cost DC motors can propel a medium sized robot. As we will see later in this article, there is a lot more involved than just a motor.

Advantages:
1) Usually low-cost.
2) Simple design and construction.
3) Near infinite different dimensions cater to your specific project.
4) Six wheels can replace a track system.
5) Diameter, width, material, weight, tread etc. can all be custom to your needs.
6) Excellent choice for beginners.
Disadvantages:
1) May lose traction (slip).
2) Small contact area (small rectangle or line).

Tracks

tracks (or treads) – треки или ступеньки
loose surfaces – рыхлые поверхности
sand and gravel – песок и гравий
the tracks to wear - износ гусениц

Tracks (or treads) are similar to what tanks use. Track drive is best for robots used outdoors and on soft ground. Although tracks do not provide added “force”, they do reduce slip and more evenly distribute the weight of the robot, making them useful for loose surfaces such as sand and gravel. Most people tend to agree that tank tracks add an “aggressive” look to the robot as well.

Advantages:
1) Constant contact with the ground prevents slipping that might occur with wheels.
2) Evenly distributed weight helps your robot tackle a variety of surfaces.
Disadvantages:
1) When turning, there is a sideways force that acts on the ground; this can cause damage to the surface the robot is being used on, and cause the tracks to wear.
2) Not many different tracks are available (robot is usually constructed around the tracks).
3) Increased mechanical complexity and connections.

Legs

uneven terrain – неровная поверхность
amateur robots – роботы, построенные любителями

An increasing number of robots use legs for mobility. Legs are often preferred for robots that must navigate on very uneven terrain. Most amateur robots are designed with six legs, which allow the robot to be statically balanced (balanced at all times on 3 legs). Robots with fewer legs are harder to balance. Researchers have experimented with monopod (one legged “hopping”) designs, though bipeds (two legs) and quadrupeds (four legs) and hexapods (6 legs) are most popular.

Advantages:
1) Closer to organic/natural motion.
2) Can potentially overcome large obstacles and navigate very rough terrain.
Disadvantages:
1) Increased mechanical, electronic and coding complexity.
2) Lower battery size despite increased power demands.
3) Higher cost to build.

Air-based

autonomous Unmanned Aerial Vehicle – автономный беспилотный летательный аппарат
appealing – привлекательный
have flown missions – выполнили задание
surveillance – наблюдение

An AUAV (Autonomous Unmanned Aerial Vehicle) is very appealing and is entirely within the capability of many robot enthusiasts. However, the advantages of building an autonomous unmanned aerial vehicles, especially if you are a beginner, have yet to outweigh the risks. High-altitude AUAV blimps and aircraft may one day be used for communication. When considering an aerial vehicle, most hobbyists still use existing commercial remote controlled aircraft. Aircraft such as the US military Predator were initially semi-autonomous though in recent years Predator aircraft have flown missions autonomously.

Advantages:
1) Remote controlled aircraft have been in existence for decades (good community).
2) Excellent for surveillance.
Disadvantages:
1) Entire investment can be lost in one crash.
2) Very limited robotic community to provide help for autonomous control.

Water-based

pool cleaning robots – роботы для очистки водоемов
flooded compartments – затопленные отсеки
thrusters, tail and fins or even wings to submerge - двигатели, хвост и плавники или даже крылья для погружения
robot can be lost many ways - робот может быть потерян многими способами
sinking, leaking, tangled - потопление, протечка воды, запутывание
surpassing depths - превышение глубины

An increasing number of hobbyists, institutions and companies are developing unmanned underwater vehicles. There are many obstacles yet to overcome to make underwater robots attractive to the wider robotic community though in recent years, several companies have commercialized pool cleaning robots. Underwater vehicles can use ballast (compressed air and flooded compartments), thrusters, tail and fins or even wings to submerge. Other aquatic robots such as pool cleaners are useful commercial products.

Advantages:
1) Most of our planet is water.
2) Design is almost guaranteed to be unique.
3) Can be used and/or tested in a pool.
Disadvantages:
1) Robot can be lost many ways (sinking, leaking, tangled…).
2) Most electronic parts do not like water (also consider water falling on electronics when accessing the robot after a dive).
3) Surpassing depths of 10m or more can require significant research and investment.
4) Very limited robotic community to provide help.
5) Limited wireless communication options.

Miscellaneous and combination / hybrid

Miscellaneous – смешанные
may be comprised – может состоять

Your idea for a robot may not fall nicely into any of the above categories or may be comprised of several different functional sections. Note again that this guide is intended for mobile robots as opposed to stationary or permanently fixed designs (other than robotic arms and grippers). It is wise to consider when building a combination / hybrid design, to use a modular design (each functional part can be taken off and tested separately). Miscellaneous designs can include hovercraft, snake-like designs, turrets and more.

Advantages:
1) Designed and built to meet specific needs.
2) Multi-tasking and can be comprised of modules.
3) Can lead to increased functionality and versatility.
Disadvantages:
1) Increased complexity and cost.
2) Often times parts must be custom designed and built.

Arms & **Grippers**

Although these do not fall under the category of "mobile" robotics, the field of robotics essentially started with arms and end-effectors (devices that attach to the end of an arm such as grippers, magnets etc). Arms and grippers are the best way for a robot to interact with the environment it is exploring. Simple robot arms can have just one motion, while more complex arms can have a dozen or more unique degrees of freedom.

Advantages:
1) Very simple to very complex design possibilities.
2) Easy to make a 3 or 4 degree of freedom robot arm (two joints and turning base).
Disadvantage:s
1) Stationary unless mounted on a mobile platform.
2) Cost to build is proportional to lifting capability.

2. Answer the questions:
What Types of Mobile Robots:
1) Can use ballast (compressed air and flooded compartments), thrusters, tail and fins or even wings to submerge?
2) Can have just about any number of wheels, although 3 and 4 are the most common?
3) Do not fall under the category of "mobile" robotics, the field of robotics essentially started with arms and end-effectors (devices that attach to the end of an arm such as grippers, magnets etc.)?
4) Do reduce slip and more evenly distribute the weight of the robot, making them useful for loose surfaces such as sand and gravel?
5) Can include hovercraft, snake-like designs, turrets and more?
6) Is very appealing and is entirely within the capability of many robot enthusiasts?

7) Are designed with six legs, which allow the robot to be statically balanced (balanced at all times on 3 legs)?

8) Can lead to increased functionality and versatility?

9) May lose traction (slip)?

10) Is excellent for surveillance?

11) Cost to build is proportional to lifting capability?

12) Can potentially overcome large obstacles and navigate very rough terrain?

13) Has increased mechanical complexity and connections?

2. Complete the table:

Types of Mobile Robots	Main principle of working	Parts, robot consists of	advantages	disadvantages
Land- based wheeled robot				
Land-based tracked robot				
Land-based legged robot				
Air-based: plane, helicopter, blimp				
Water-based; boat, submarine				
Misc. and combination robot				
Stationary robot (arm, manipulator etc.)				

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