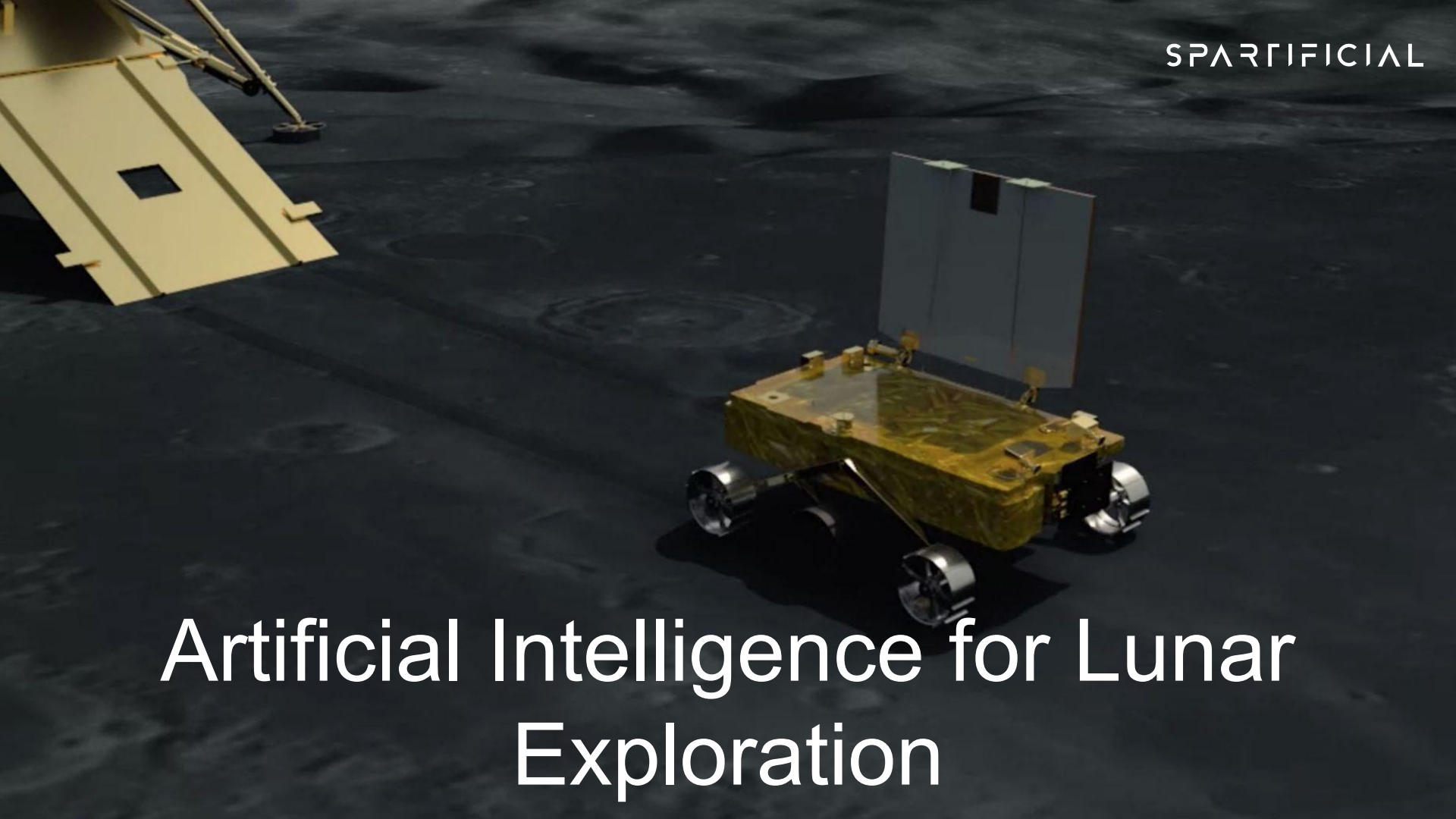


Artificial Intelligence for Lunar Exploration

SPARTIFICIAL

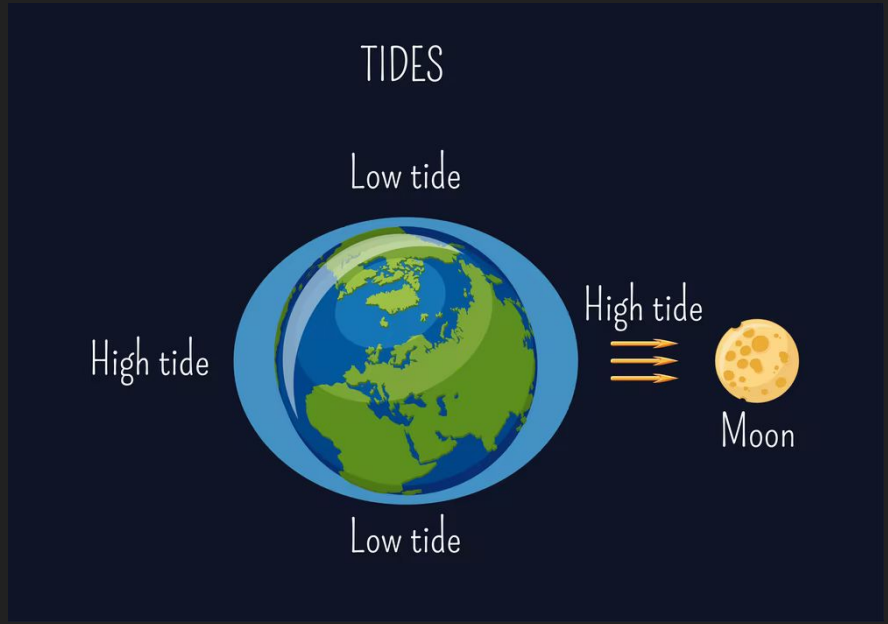
INDEX

Why moon is important?

1. Distance - Closest Astronomical Object to the Earth

Why moon is important?

1. Distance - Closest Astronomical Object to the Earth
2. It also causes tides, creating a rhythm that has guided humans for thousands of years.

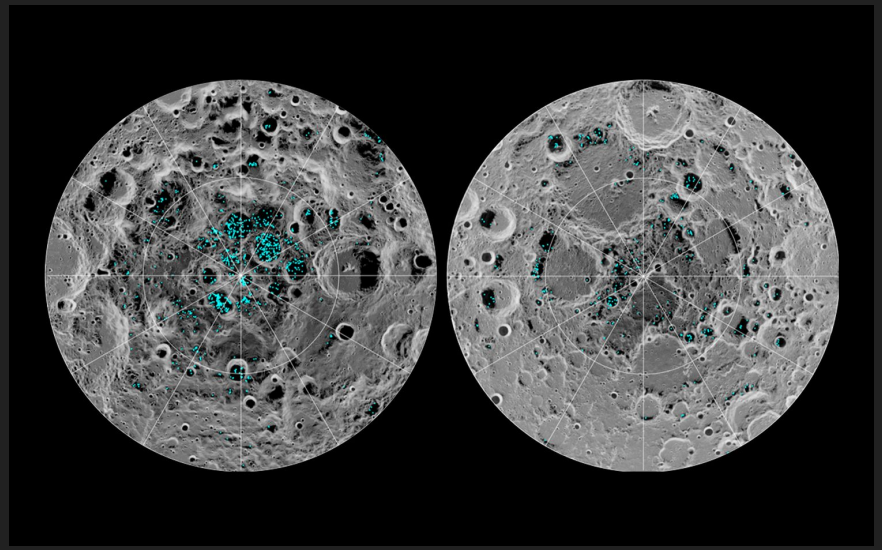


Why moon is important?

1. Distance - Closest Astronomical Object to the Earth
2. It also causes tides, creating a rhythm that has guided humans for thousands of years.
3. The Moon also has technological and economic value.

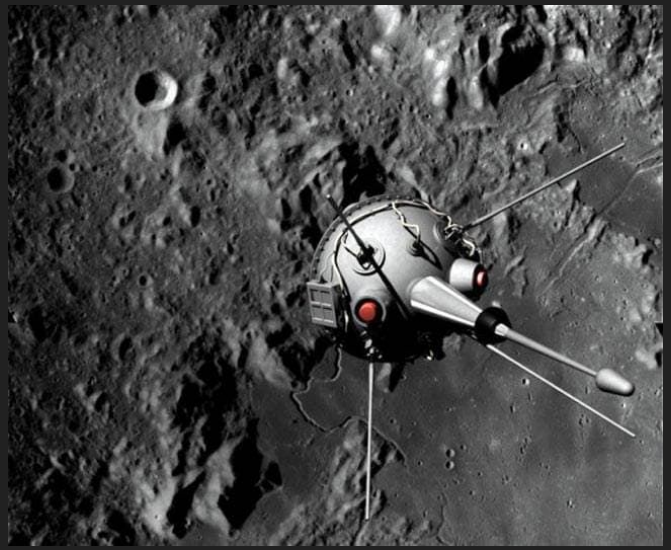
Why moon is important - last discoveries?

In the last two decades,
NASA and ISRO spacecraft have discovered water ice on the Moon's poles. Future human habitats on the Moon could tap into this water ice for drinkable water, breathable air and rocket fuel.



Previous Moon Missions

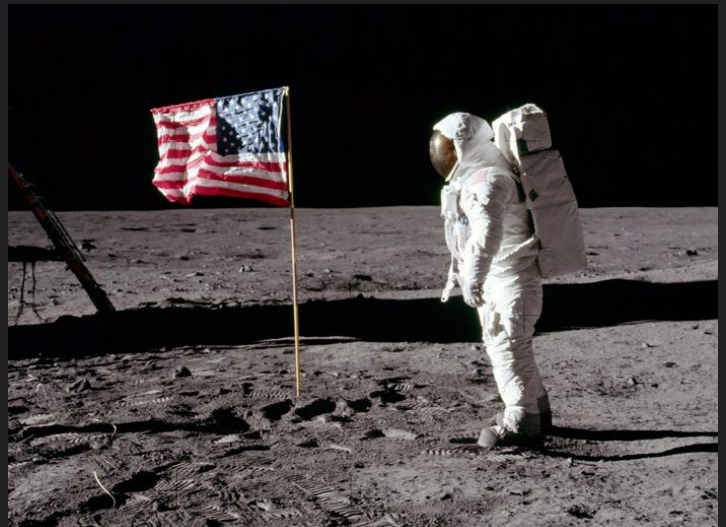
- Luna 2- This unmanned Soviet probe became the first man-made object to make contact with another planetary body. The spherical spacecraft launched on Sept. 12, 1959 and impacted the moon two days later.



Previous Moon Missions

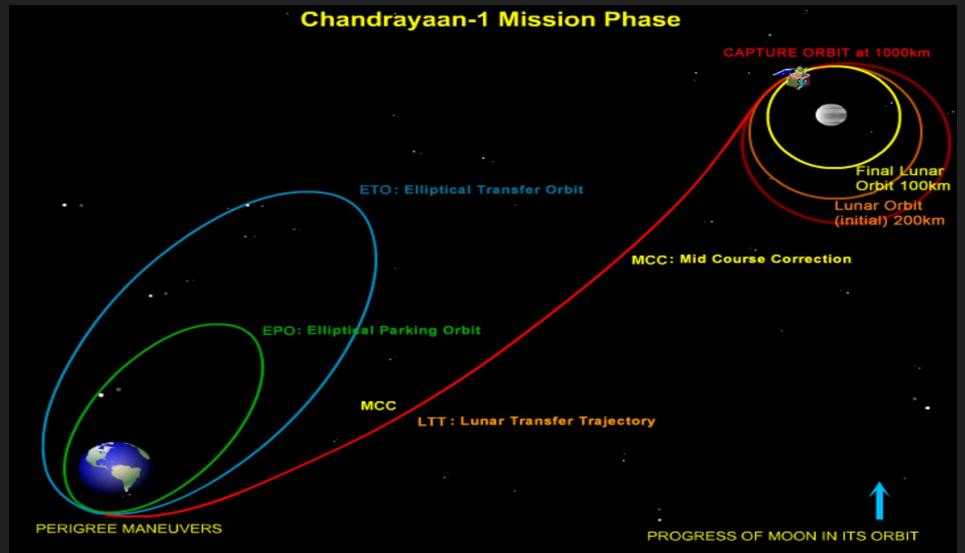
- Luna 2

- Apollo - The Apollo program by NASA accomplished landing the first humans on the Moon from 1969 to 1972. During the Apollo 11 mission, astronauts Neil Armstrong and Buzz Aldrin landed their Apollo Lunar Module (LM) and walked on the lunar surface, while Michael Collins remained in lunar orbit in the command and service module.



Previous ISRO Moon Missions-

- **Chandrayaan-1**- Launched on Oct. 22, 2008, India's first mission beyond Earth, the probe observed the moon from orbit until August 2009.
- In September 2009, results from one of Chandrayaan-1's instruments, the Moon Mineralogy Mapper, helped detect evidence for water on the moon.



Previous ISRO Moon Missions-

Chandrayaan-2- Launched on 22 July, 2019, it is the second lunar exploration mission developed by ISRO.
It consists of a lunar orbiter, and also included the Vikram lander, and the Pragyan lunar rover, all of which were developed in India.
The main scientific objective is to map and study the variations in lunar surface composition, as well as the location and abundance of lunar water. Unfortunately, the lander crashed while landing due to a software glitch.

Upcoming Moon Missions-

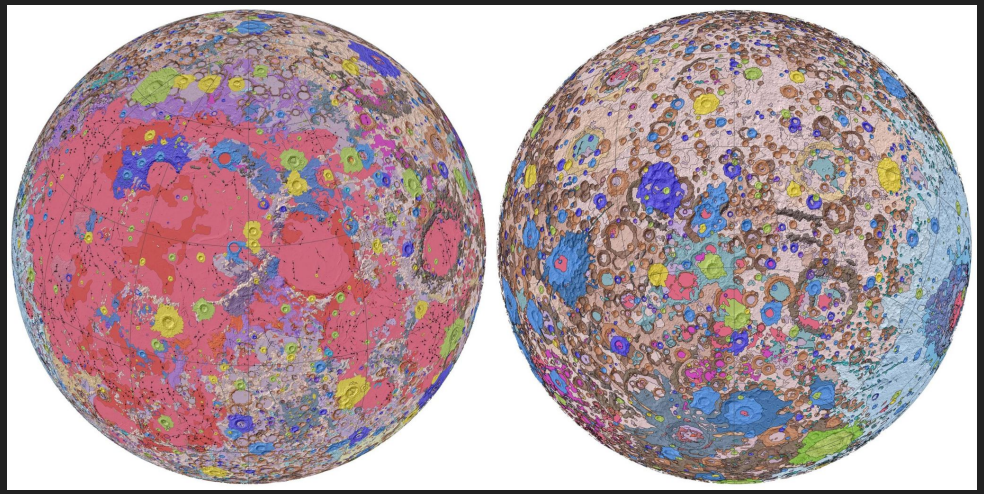
- **Chandrayaan-3** - It will be a mission repeat of Chandrayaan-2 but will only include a lander and rover similar to that of Chandrayaan-2. It will not have an orbiter. The spacecraft is planned to be launched in the third quarter of 2022. (We need to hurry!!)

Upcoming Moon Missions-

ARTEMIS - The **Artemis program** is a United States-led international human spaceflight program. Its primary goal is to return humans to the Moon, specifically the lunar south pole, by 2025. If successful, it will include the first crewed lunar landing mission since Apollo 17 in 1972, the last lunar flight of the Apollo program.

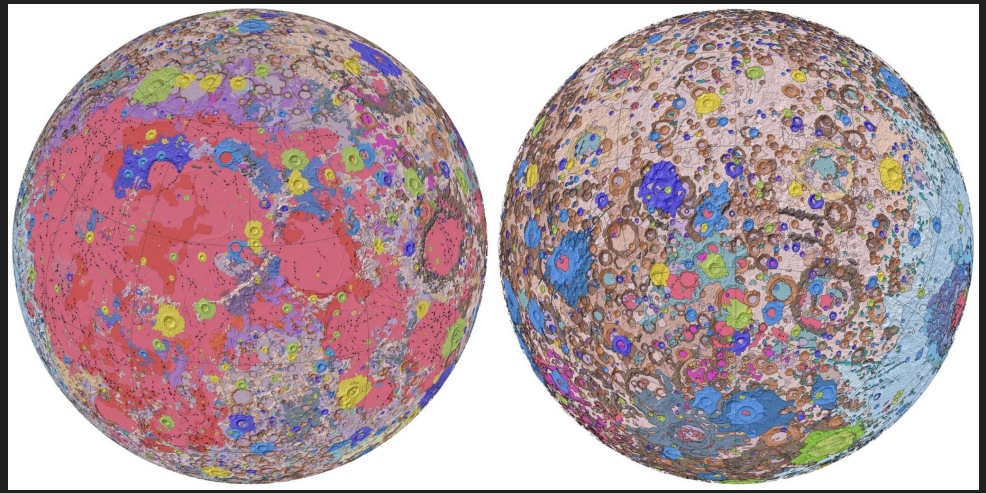
Lunar Mineralogy

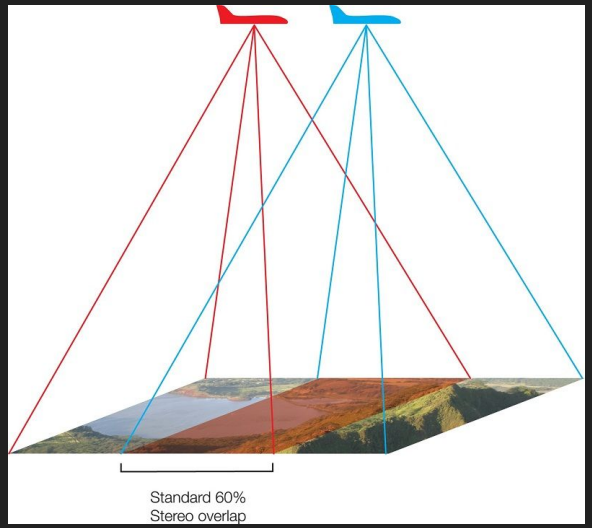
SPARTIFICIAL



Topographic map of the front and far sides of the Moon, in which stereo data provided elevation differences from high resolution photographs and radar altimetry data, acquired by the Clementine spacecraft as it orbited the lunar surface.

Lunar Mineralogy





stereo data

Topographic map of the front and far sides of the Moon, in which stereo data provided elevation differences from high resolution photographs and radar altimetry data, acquired by the Clementine spacecraft as it orbited the lunar surface.

Lunar minerals do not react appreciably with the Earth's atmosphere, although akaganeite (FeO(OH)) was found on the surface of one Apollo 16 breccia. Slow oxidation of metallic Fe grains does occur, but the classic problem of catalytic oxidation by lawrencite (FeCl 2) does not seem to be the problem that it is with some meteorites. The Apollo Lunar Sample Collection is preserved in dry nitrogen cabinets.

To know more about the image in detail-
https://astrogeology.usgs.gov/search/map/Moon/Geology/Unified_Geologic_Map_of_the_Moon_GIS_v2

List of minerals reported in Lunar samples

Major phases	Rough formula
Plagioclase	$Ca_2Al_2Si_2O_8$
Pyroxene	$(Ca,Mg,Fe)_2Si_2O_6$
Olivine	$(Mg,Fe)_2SiO_4$
Ilmenite	$FeTiO_3$

New minerals	
Armalcolite	$(Mg,Fe)(Ti,Zr)_2O_5$
Tranquillityite	$Fe_8(Zr,Y)_2Ti_3Si_3O_{24}$
Pyroxferroite	$CaFe_6(SiO_3)_7$
Yttrobetafite	$(Ca,Y)_2(Ti,Nb)_2O_7$

Minor phases	
Iron	Fe (Ni,Co)
Troilite	FeS
Silica	SiO_2
Chromite-ulvospinel	$FeCr_2O_4$-Fe_2TiO_4
Apatite	$Ca_5(PO_4)(F,Cl)$
Merrillite	$Ca_3(PO_4)_2$
Ternary feldspar	$(Ca,Na,K)AlSi_3O_8$
K-feldspar	$(K,Ba)AlSi_3O_8$
Pleonaste	$(Fe,Mg)(Al,Cr)_2O_4$
Zircon	$(Zr,Hf)SiO_4$
Baddeleyite	ZrO_2
Rutile	TiO_2
Zirkelite-zirconolite	$(Ca,Fe)(Zr,Y,Ti)_2O_7$

Uses of Olivine

Most olivine is used in metallurgical processes as a slag conditioner. High-magnesium olivine (forsterite) is added to blast furnaces to remove impurities from steel and to form a slag.

Plagioclase

Plagioclase is used in the manufacture of glass and ceramics; the iridescent varieties peristerite and labradorite are valued as gemstones or ornamental material. The primary importance of plagioclase, however, derives from its role in rock formation.

Lunar Environment and gravity

Earth's Moon is the only place beyond Earth where humans have set foot. The Earth's moon presents a **hostile environment.**

Lunar Environment and gravity

The moon's surface is covered with a thin layer of fine, charged, reactive dust capable of entering habitats, and vehicle compartments, where it can cause crew member health problems.

SOIL COMPOSITION

The lunar regolith is chemically composed of several elements and compounds in varying concentrations.

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The carbon, hydrogen, and nitrogen found in the soil are almost entirely due to implantation by the solar winds.

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- The lunar regolith is chemically composed of several elements and compounds in varying concentrations.
- The carbon, hydrogen, and nitrogen found in the soil are almost entirely due to implantation by the solar winds.
- Unlike most Earth soils, the lunar soil has high concentrations of sulfur, iron, magnesium, manganese, calcium, and nickel.
- Many of these elements are found in oxides such as FeO, MnO, MgO, etc. Ilmenite ($FeTiO_3$), most common in the mare regions, is the best source of in situ oxygen.

ATMOSPHERE

Contrary to popular perceptions, the Moon does have an atmosphere.

However, it is extremely thin.

To illustrate, the entire lunar atmosphere, compressed to Earth surface temperature and pressure, would fit into a 210 foot cube.

ATMOSPHERE

Although the research is not complete, helium, argon, sodium, and potassium have been identified as atmospheric elements.

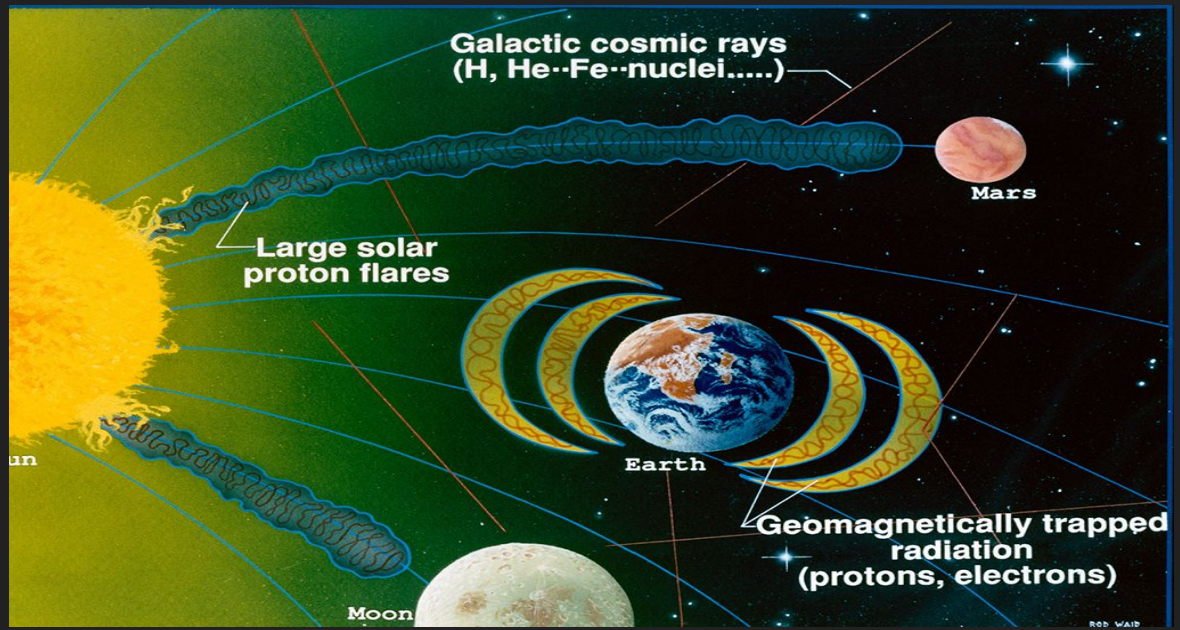
Of these, the helium most likely comes from the solar wind, while the argon originates in the lunar interior.

The discovery of sodium and potassium gives the lunar atmosphere important (research-wise) similarities to the atmospheres of Mercury.

Radiation Source	Energy	Flux (cm-2s-1)	Penetration Depth
cosmic rays	1-10 Gev/nucleon	1	few meters
solar flares	1-100 Mev/nucleon	100	1 cm
solar wind	1000 ev/nucleon	108	10-8 cm

SPARTIFICIAL

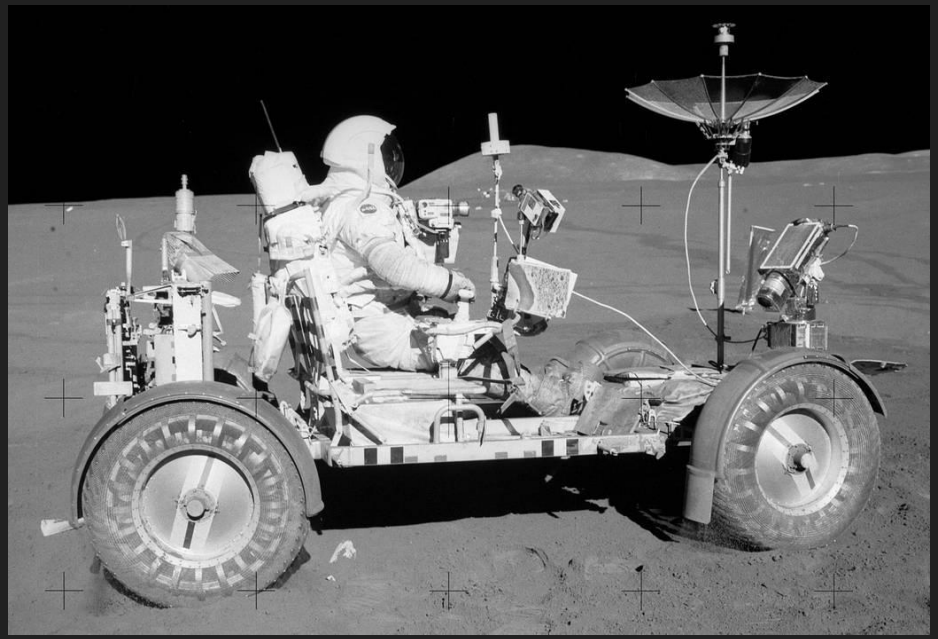
Radiation source on moon

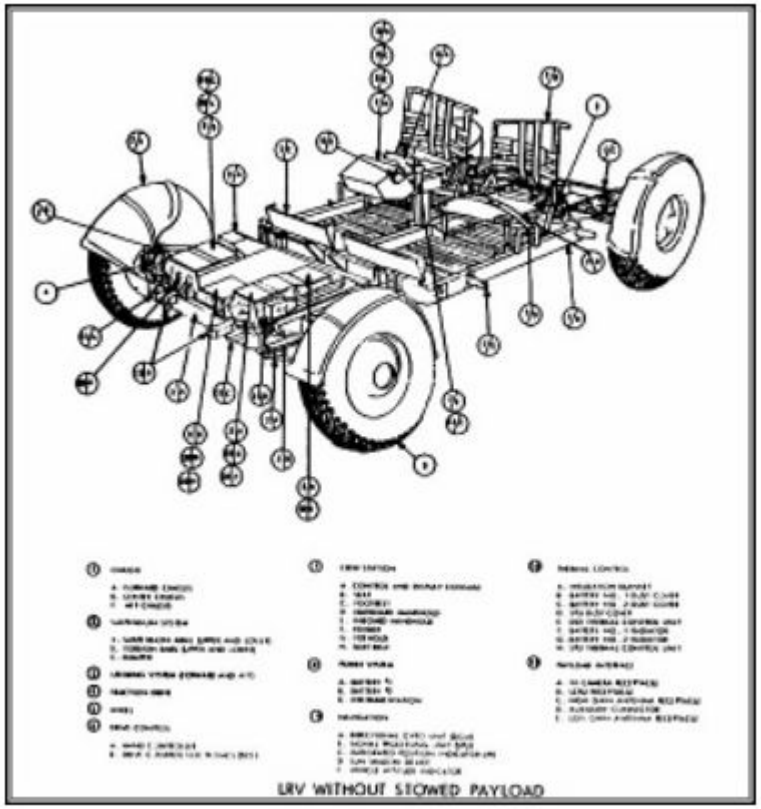


Brief intro of a typical lunar rover

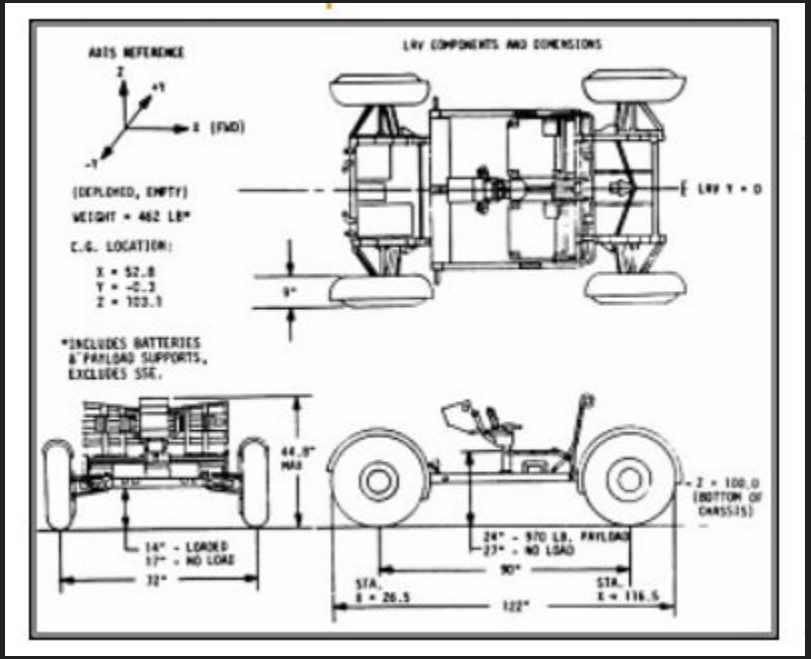
- The lunar roving vehicle transported two astronauts during Apollo 15,16 and 17 missions.
- The LRV (Lunar roving vehicle) carried tools, scientific equipment, communications systems and gear, and lunar samples.
- The four-wheel, lightweight vehicle greatly extended the lunar area that could be explored by humans.
- The LRV could be operated by either astronaut.

The LRV was the first manned surface transportation system designed to operate on the Moon. It marked the beginning of a new technology and represented an experiment to overcome many new and challenging problems for which there was no precedent in terrestrial vehicle design and operations.





More the vehicle can be found in : https://airandspace.si.edu/explore-and-learn/topics/apollo/apollo-program/spacecraft/lrv.cfm



LVR description:
https://airandspace.si.edu/explore-and-learn/topics/apollo/apollo-program/spacecraft/lrv.cfm

Importance of Autonomous Rovers

- Autonomous rovers can greatly amplify the productivity of the small crew.

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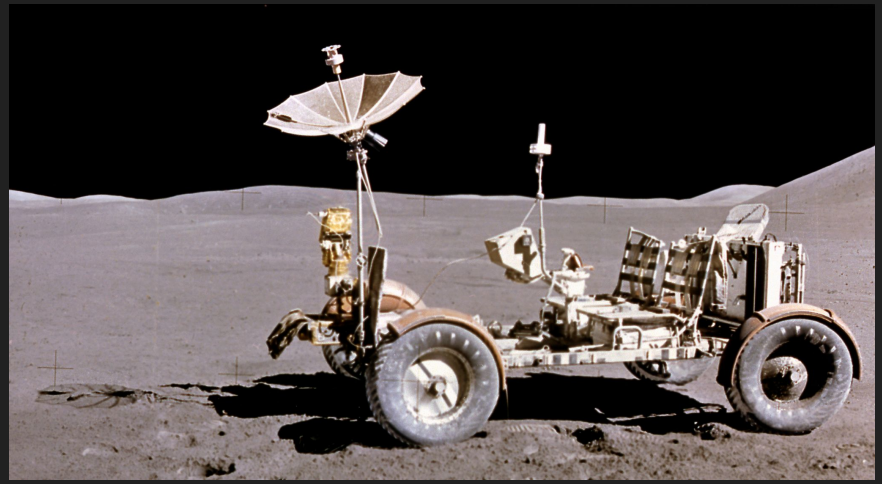
- To avoid getting damaged, as well as to diagnose and correct recoverable software and hardware failures.

Importance of Autonomous Rovers

SPARTIFICIAL

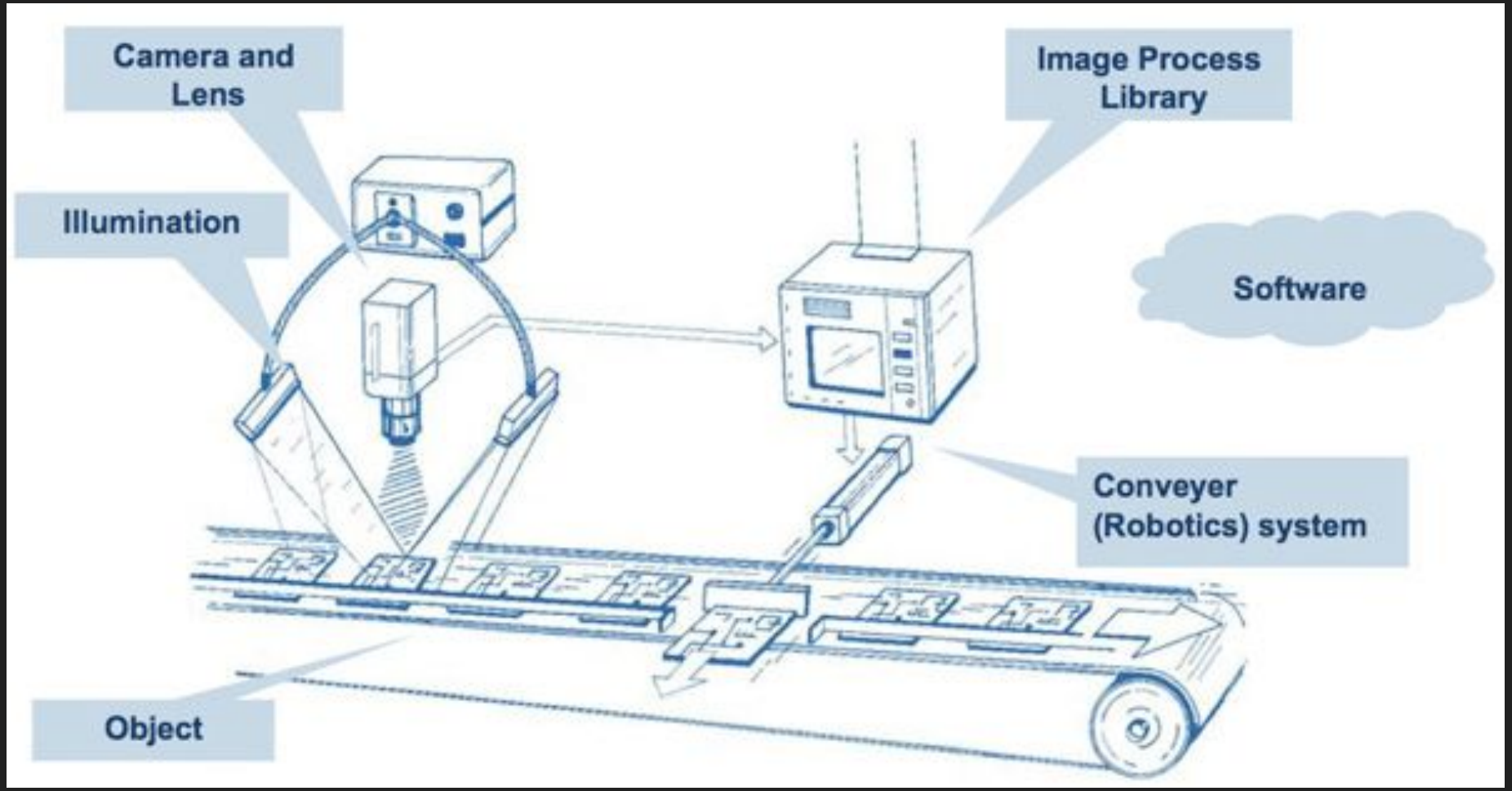
- Autonomous rovers can greatly amplify the productivity of the small crew.
- It is also advantageous for the rovers to be responsible for their own well-being.
- To avoid getting damaged, as well as to diagnose and correct recoverable software and hardware failures.
- With robust autonomous rovers, the crew does not have to spend time babysitting rovers and can concentrate on survival and science.



Machine Vision

- Machine vision is the ability of a computer to perceive its environment.
- One or more video cameras are used with analog-to-digital conversion and digital signal processing.
- The image data is sent to a computer or robot controller.
- It is used in a variety of industrial processes, like pattern recognition, object recognition, optical character recognition etc.

https://aijourn.com/what-is-machine-vision-everything-you-need-to-know/


Camera and Lens
Image Process Library
Illumination
Software
Conveyer (Robotics) system
Object

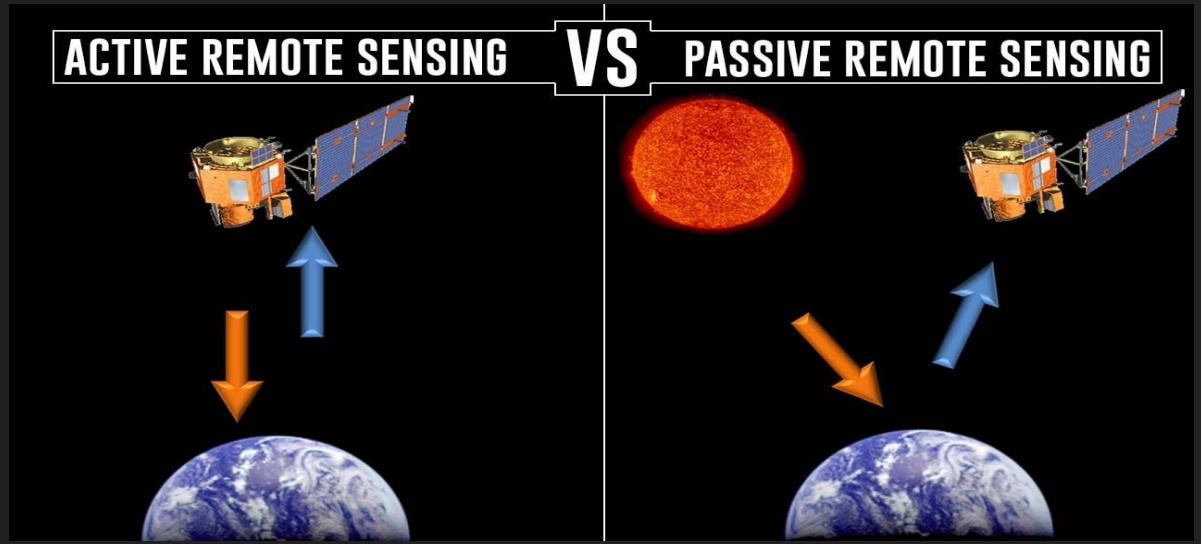
Components involved in machine vision

These components of machine vision systems typically include the following five elements:

- The lighting system
- The optical system or lens
- The sensor
- The vision processing system
- The communications system

Lighting

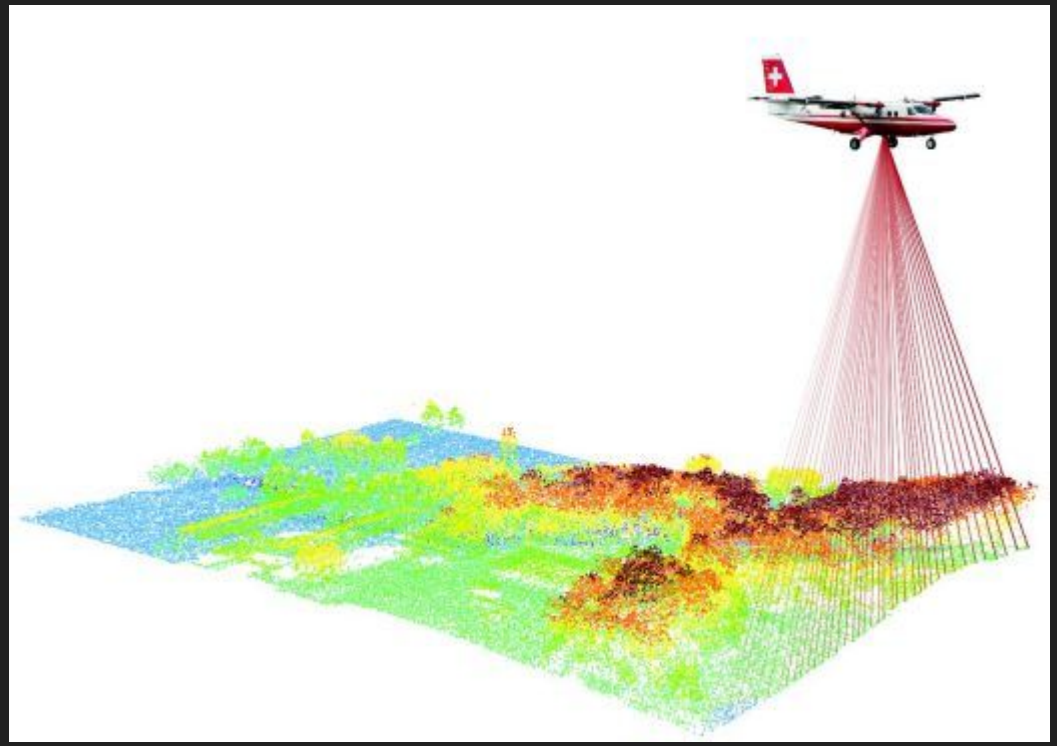
- The selection of lighting for use in a machine vision system should be made with the goal of maximizing the contrast for whatever features are of interest to be measured or observed while minimizing the contrast of all other features of the part.



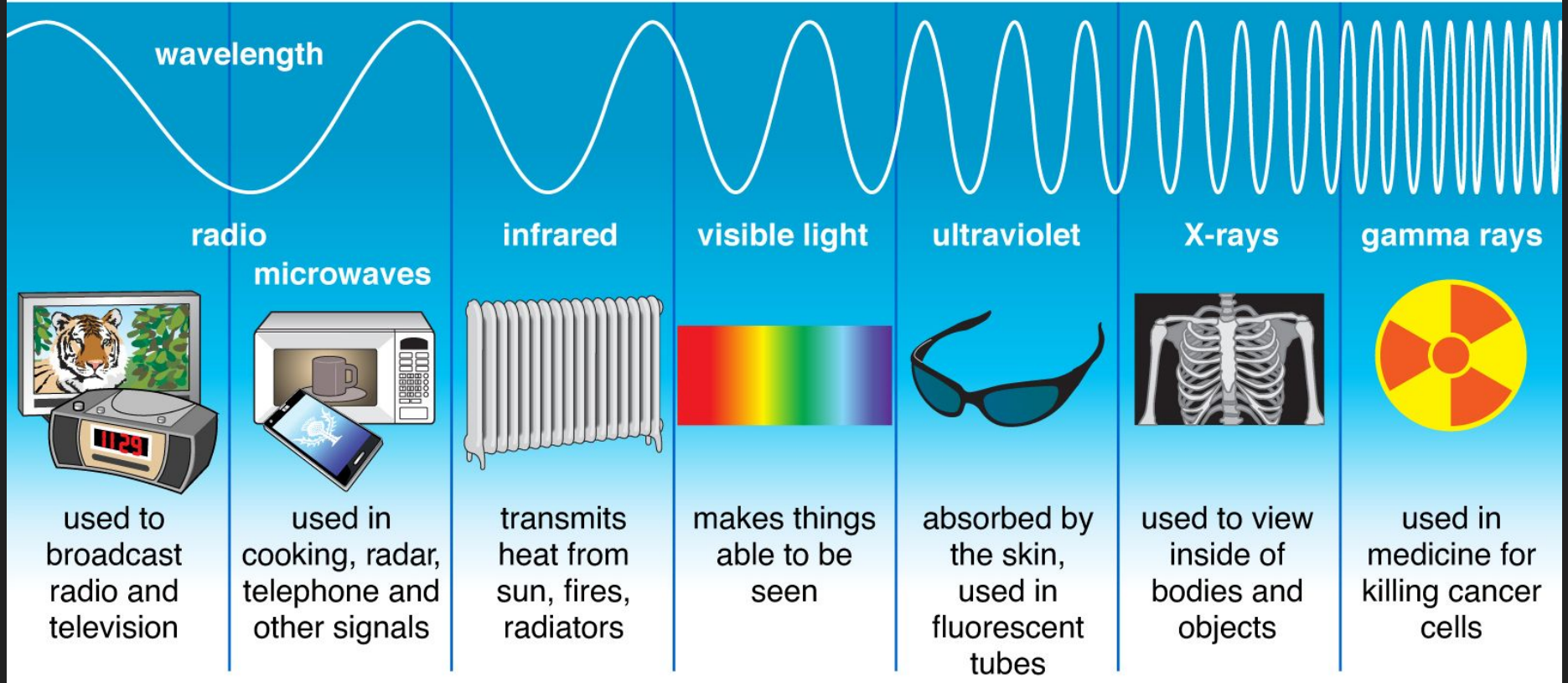
Lighting

- Achieving this goal may require varying the amount of light used (intensity), the style of lighting (dome vs. ring light, for example) and the placement of the light source relative to the part and the optical system or camera.
- Altering these basic parameters can markedly improve a machine vision system’s ability to consistently identify and measure the part feature(s) being monitored.
- Lighting options include LED lighting and strobe lights for capturing images with fast shutter speeds.

SPARTIFICIAL

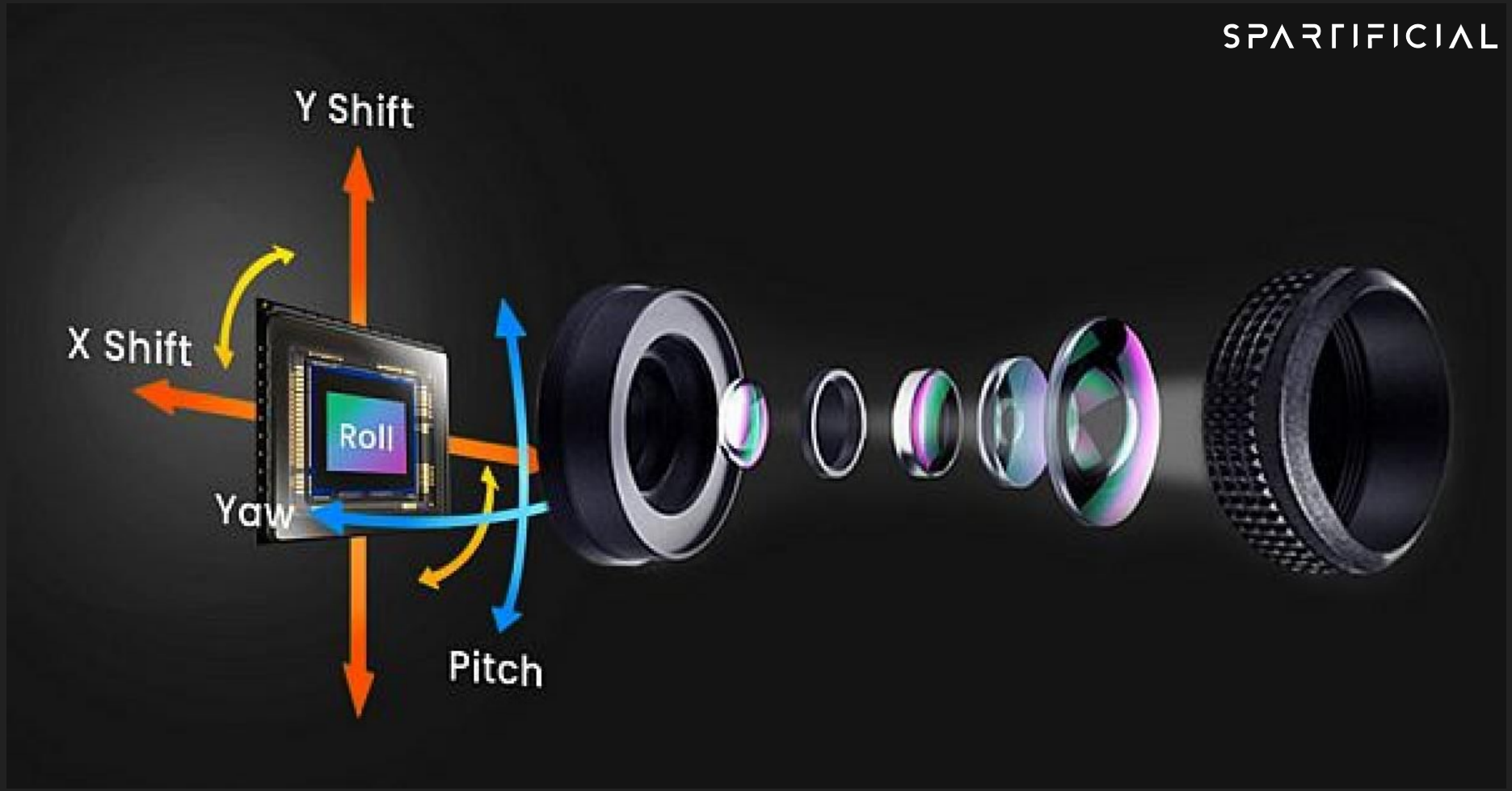


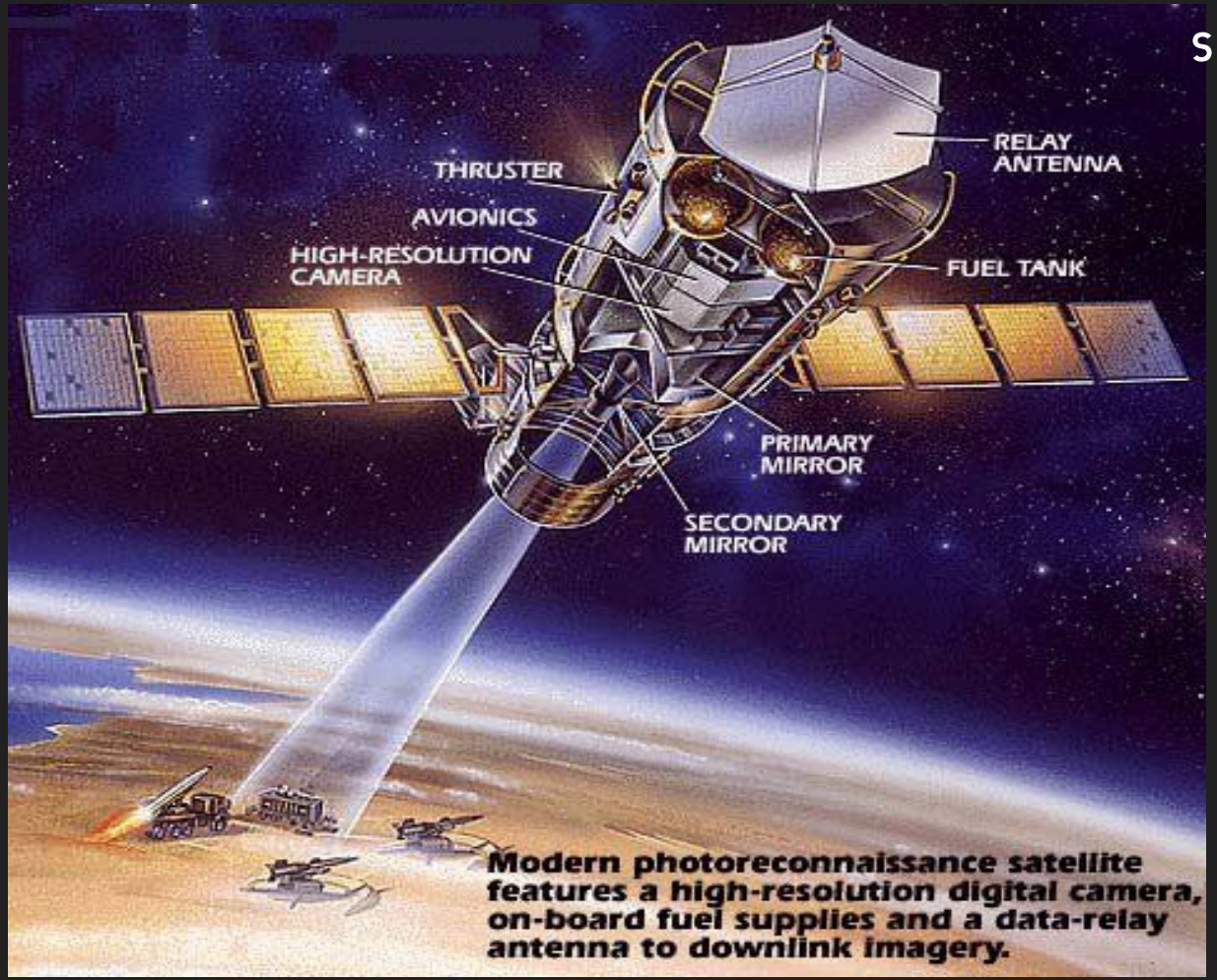
Types of Electromagnetic Radiation



Optical System

- The optical components in a machine vision system are typically a lens or a camera, which integrates the lens with other elements such as the sensor.
- The lens selection will establish the field of view, which is the two-dimensional area over which observations can be made.
- The lens also will determine the depth of focus and the focal point, both of which will relate to the ability to observe features on the parts being processed by the system.



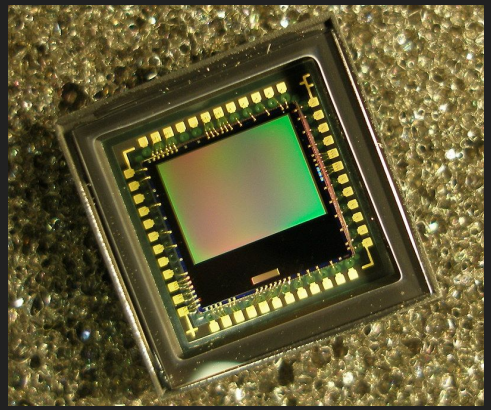

RELAY ANTENNA
THRUSTER
AVIONICS
HIGH-RESOLUTION CAMERA
FUEL TANK
PRIMARY MIRROR
SECONDARY MIRROR
Modern photoreconnaissance satellite features a high-resolution digital camera, on-board fuel supplies and a data-relay antenna to downlink imagery.

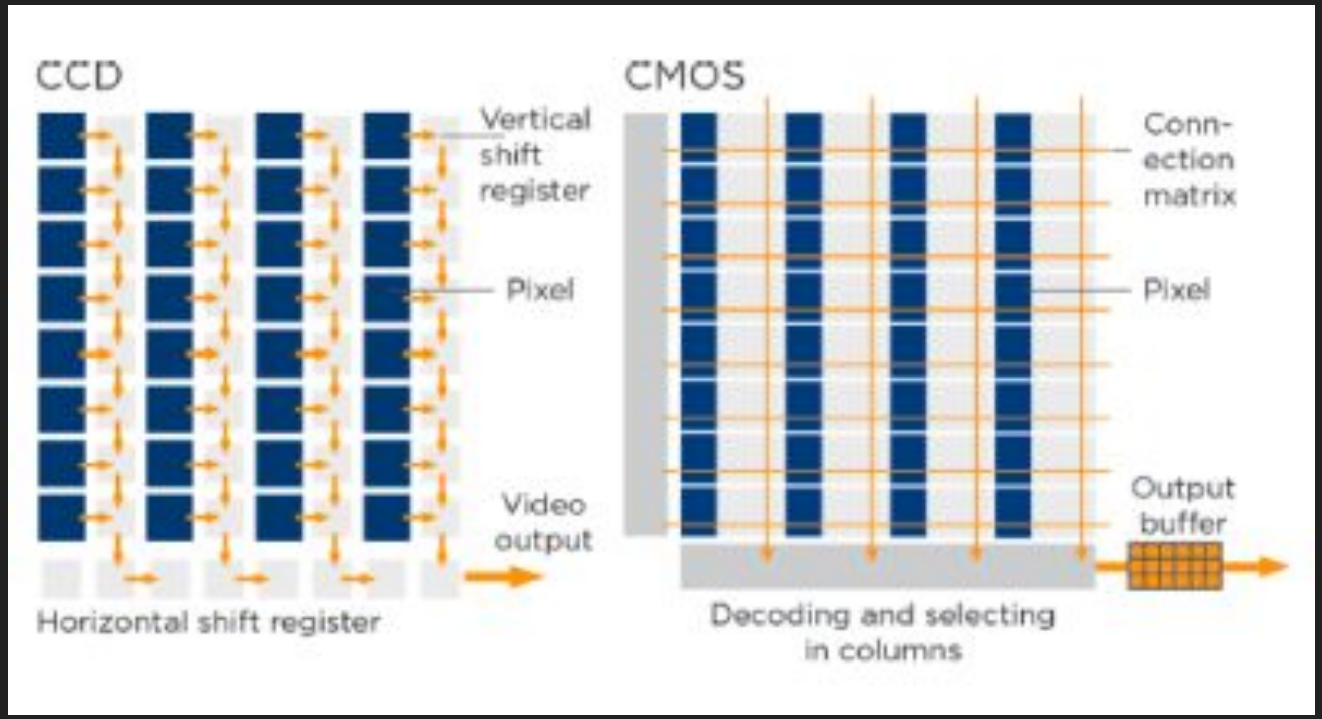
- Lenses may be interchangeable or may be fixed as part of some designs that use a smart camera for the optical system.
- Lenses that have a longer focal length will provide higher magnification of the image but will reduce the field of view.
- The selection of the lens or optical system for use is dependent on the specific function being performed by the machine vision system and by the dimensions of the feature under observation.
- Color recognition capability is another characteristic of the optical system element.

Sensor

- Sensors used in machine vision systems serve to capture the light from the optical system and convert that into a digital image.
- Sensors use CMOS or CCD technology to capture the light and convert that to a set of pixels that show the presence of light in the different areas of the original part being observed.
- Sensors are measured by their resolution, which is an indication of the number of pixels available in the digital image.

SPARTIFICIAL

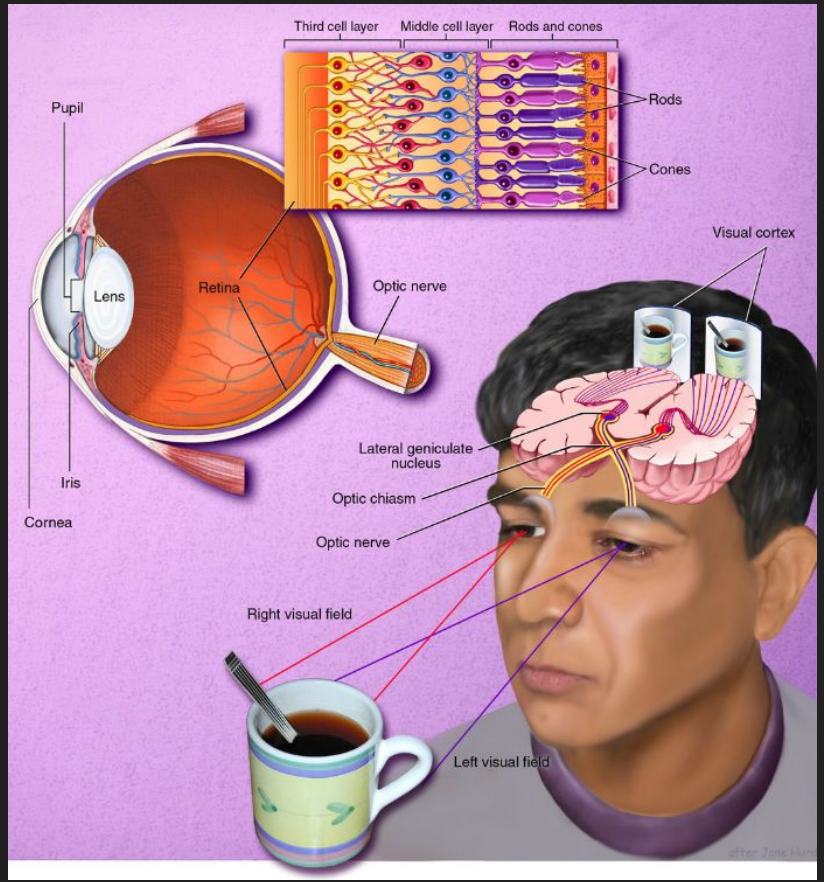


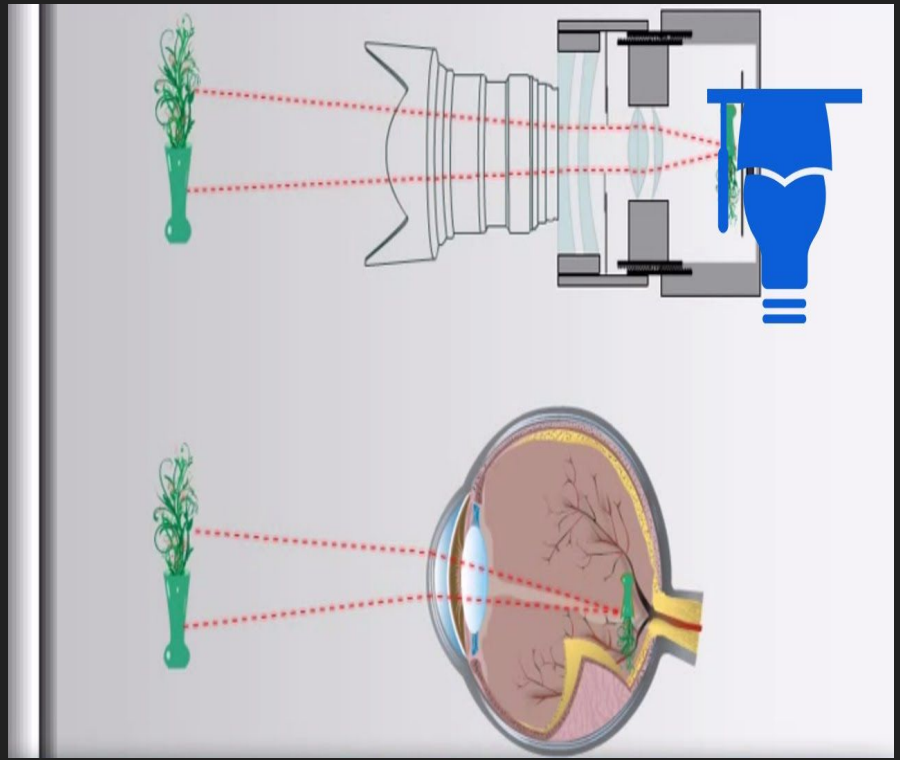

CCD
Vertical shift register
Pixel
Video output
Horizontal shift register
CMOS
Conn-ection matrix
Pixel
Output buffer
Decoding and selecting in columns

- Sensors that have higher resolution can produce images with more pixels, which generally translates to more image quality and a greater ability to resolve details.
- The resolution of the sensor is related to the sizes of the parts being observed, the dimensions of the measurements being made, the tolerances of those measurements, and other application parameters.
- Higher resolutions will increase the accuracy of measurements made by the machine vision system

Vision Processing

The vision processing element of the machine vision system takes the data from the digital image and uses software to perform specific functions that are then used to evaluate the part under observation. These evaluations are pre-programmed conditions that define the acceptance and rejection criteria for the part being observed.


Third cell layer
Middle cell layer
Rods and cones
Rods
Cones
Pupil
Lens
Retina
Optic nerve
Visual cortex
Lateral geniculate nucleus
Optic chiasm
Optic nerve
Iris
Cornea
Right visual field
Left visual field

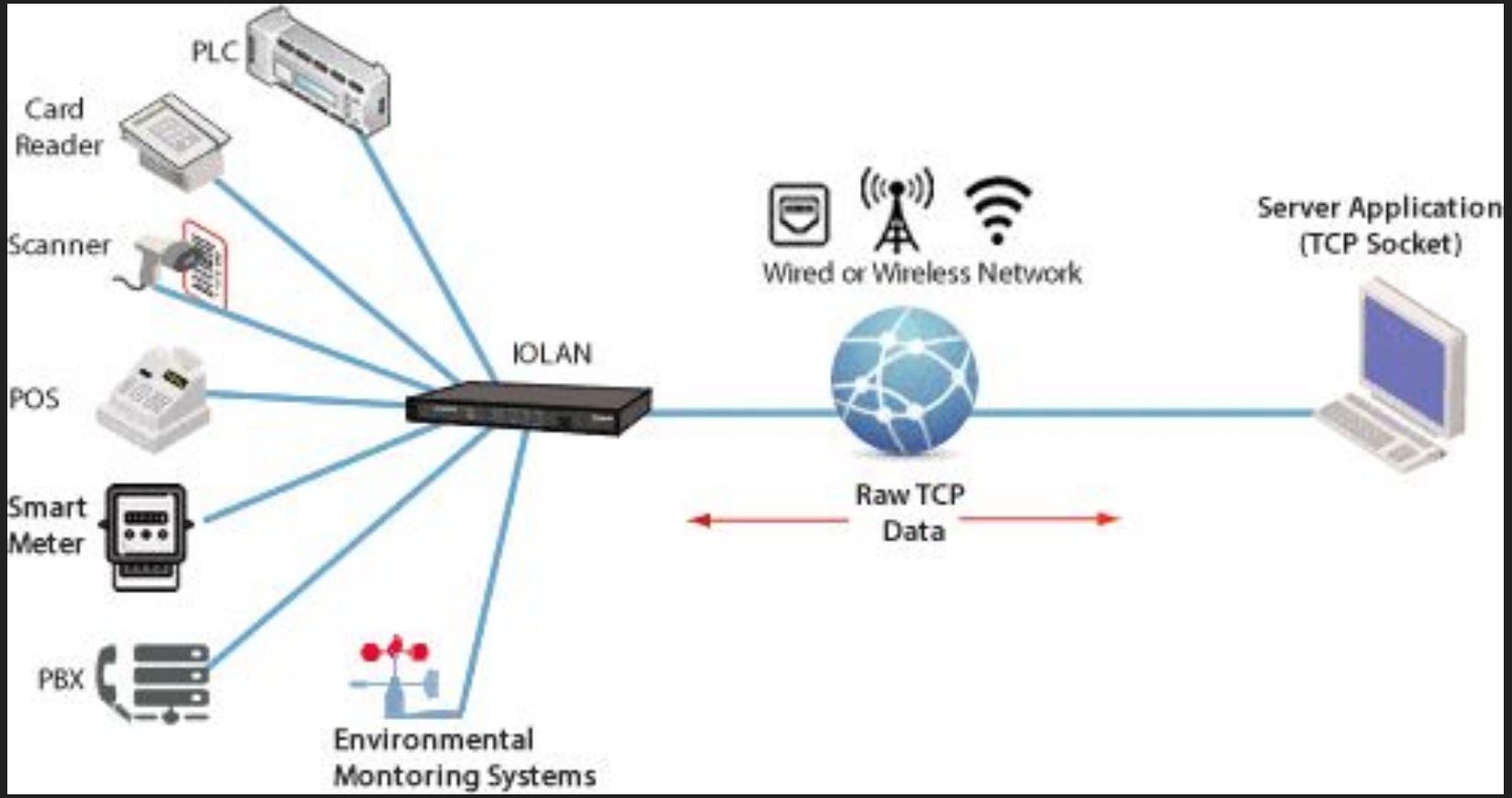


The steps performed by the vision processing system include:

1. Acquiring the digital image from the sensor
2. Pre-processing the image as needed to optimize it for measurements
3. Analyzing the image to locate the specific features of the part that need to be measured or observed
4. Collecting measurements of the needed features and comparing those values against the defined dimensional criteria for that feature
5. Establishing a result, usually as a pass-fail or go/no-go condition for that part

Communications

- Once the vision processing element has completed its steps, the last element in the machine vision system involves the communications protocol.
- The purpose of this element is to provide a usable output in a standardized format that can provide a usable signal to drive other components in the production process based upon the output from the vision processing system.
- Standardized outputs include discrete I/O signals or serial data such as RS-232 or Ethernet sent to a logging device or other system that will make use of the data.

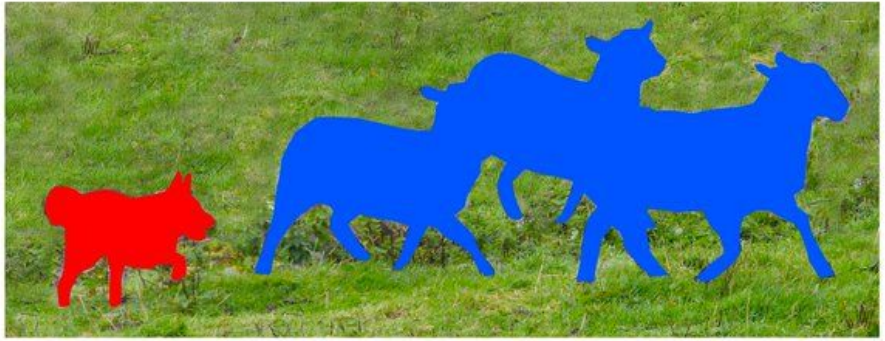

PLC
Card Reader
Scanner
POS
Smart Meter
PBX
IOLAN
Environmental Montoring Systems
Wired or Wireless Network
Server Application (TCP Socket)
Raw TCP Data

- A discrete I/O signal may be fed to a PLC that will use that to light a stack light, or power solenoid driven actuator to move a rejected part out of the main production pathway.
- A serial RS-232 data feed might be fed to an HMI screen to display information to an operator overseeing the production process.
- System integrators can assist with the process of embedding communication signals between machine vision systems and other machines in the production cell.

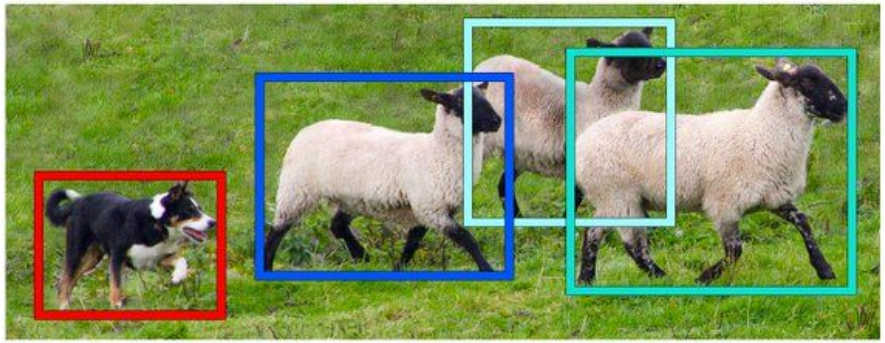
Image Segmentation

- Image segmentation is a commonly used technique in digital image processing and analysis to partition an image into multiple parts or regions, often based on the characteristics of the pixels in the image.
- Image segmentation could involve separating foreground from background, or clustering regions of pixels based on similarities in color or shape.

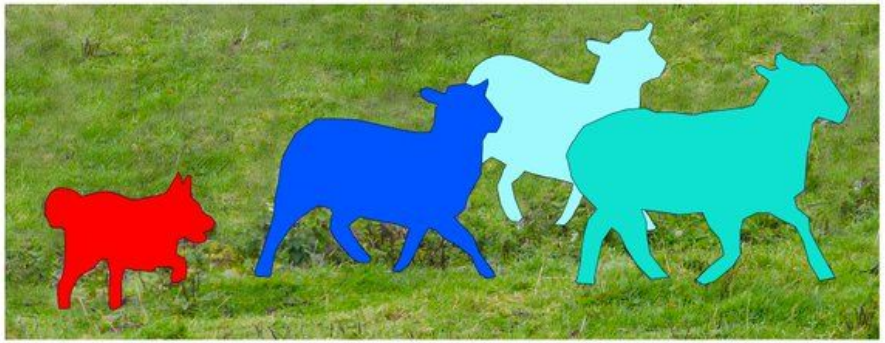
Image Recognition



Semantic Segmentation



Object Detection



Instance Segmentation

Cameras used in previous machine vision projects

- Allied Vision
- Basler
- Cognex
- FLIR Machine Vision
- IDS Imaging Development Systems
- Imperx
- JAI
- Keyence
- Sony
- Teledyne DALSA

Difference between Machine Vision and Computer Vision

- Computer vision and machine vision are overlapping technologies.
- A machine vision system requires a computer and specific software to operate while computer vision doesn’t need to be integrated with a machine. Computer vision can, for example, analyze digital online images or videos as well as “images” from motion detectors, infrared sensors or other sources, not just a photo or video.
- Machine vision is a subcategory of computer vision.

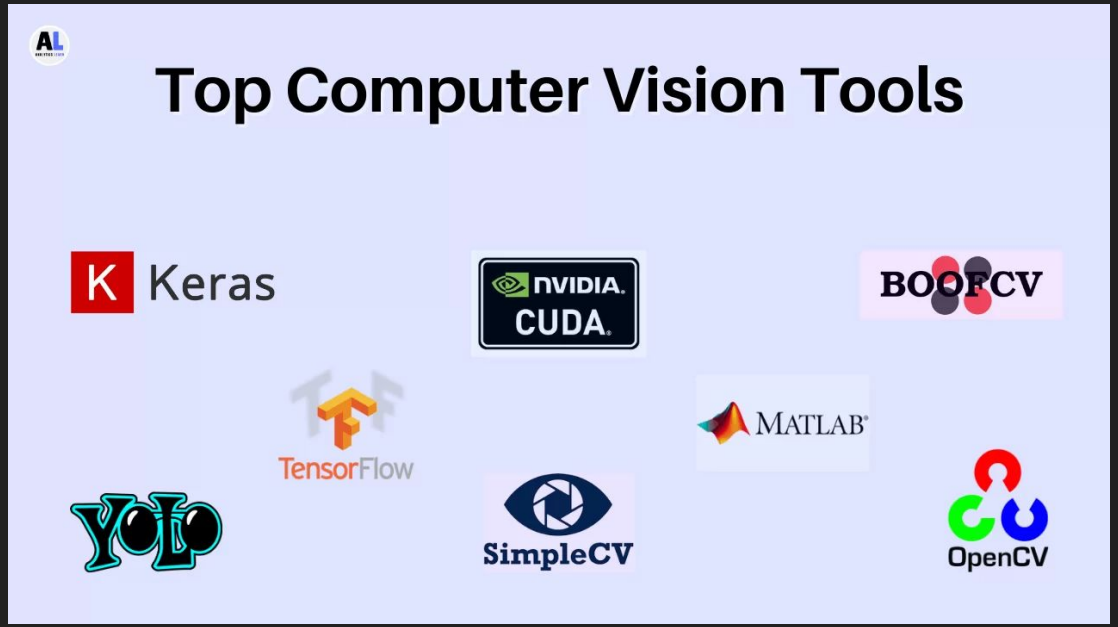
Computer vision

- Computer vision is the field of computer science that focuses on replicating parts of the complexity of the human vision system and enabling computers to identify and process objects in images and videos in the same way that humans do.
- It is a field of AI that enables computer to derive meaningful information from digital images and other visual inputs.


traffic light
traffic light
traffic light
traffic light
traffic light
bus
truck
car
car
car
truck
truck
person
person
person
person
handbag
person
car
person
person

Commonly used tools in computer vision

- OpenCV
- TensorFlow
- CUDA
- Pytorch
- MATLAB
- Keras
- SimpleCV
- BoofCV
- CAFFE
- OpenVINO
- DeepFace
- YOLO



```
(keras_gpu) C:\Users\shikh>conda list cuda
# packages in environment at C:\Users\shikh\anaconda3\envs\keras_gpu:
#
# Name                    Version                   Build  Channel
cudatoolkit               10.0.130                      0    anaconda

(keras_gpu) C:\Users\shikh>conda list cuDNN
# packages in environment at C:\Users\shikh\anaconda3\envs\keras_gpu:
#
# Name                    Version                   Build  Channel
cudnn                     7.6.5                cuda10.0_0    anaconda

(keras_gpu) C:\Users\shikh>conda list keras-gpu
# packages in environment at C:\Users\shikh\anaconda3\envs\keras_gpu:
#
# Name                    Version                   Build  Channel
keras-gpu                 2.3.1                         0    anaconda

(keras_gpu) C:\Users\shikh>conda list tensorflow
# packages in environment at C:\Users\shikh\anaconda3\envs\keras_gpu:
#
# Name                    Version                   Build  Channel
tensorflow                1.14.0          gpu_py37h5512b17_0    anaconda
tensorflow-base           1.14.0          gpu_py37h55fc52a_0    anaconda
tensorflow-estimator      1.14.0                        py_0    anaconda
tensorflow-gpu            1.14.0                h0d30ee6_0    anaconda
```

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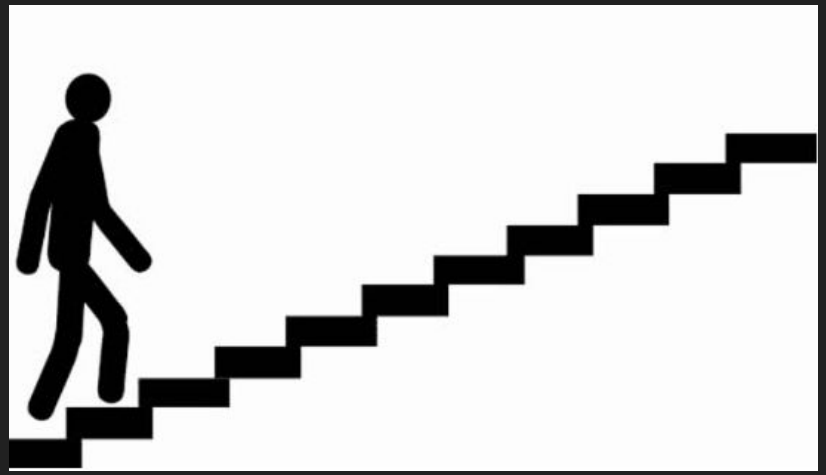
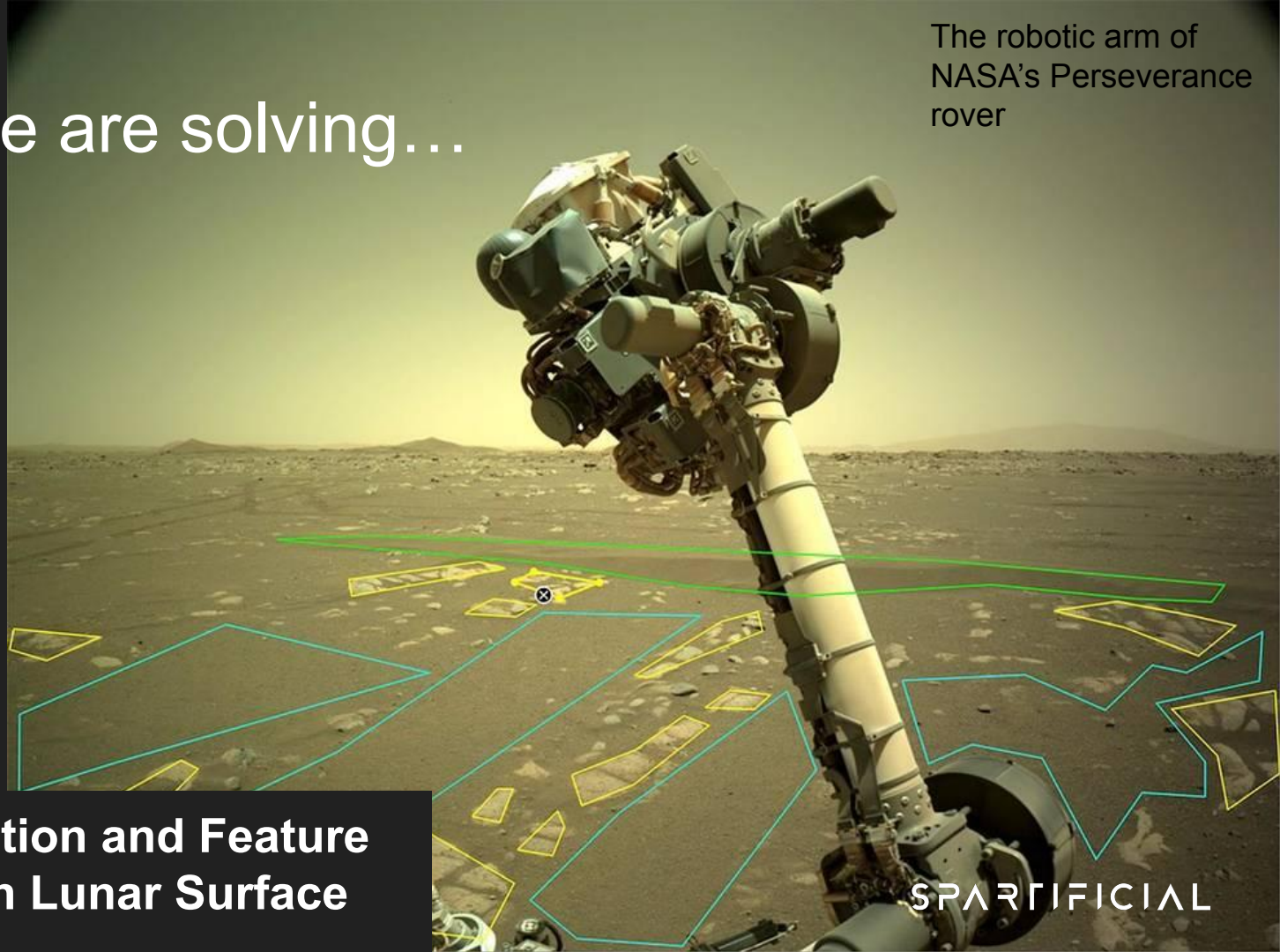
CONTINUE



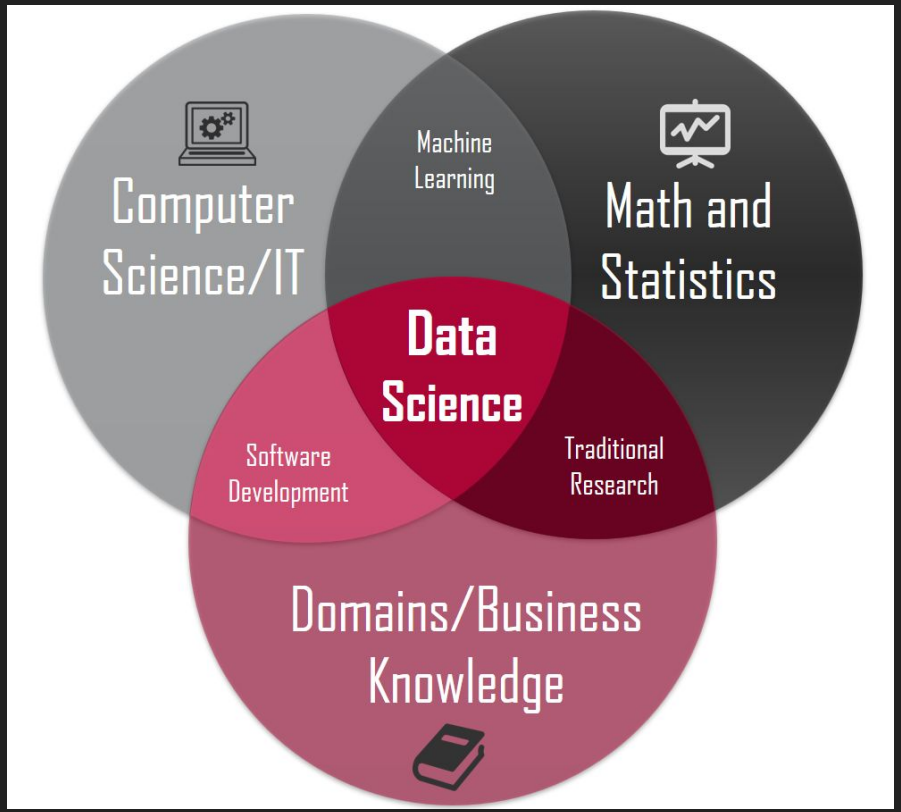
Problem, we are solving…



The robotic arm of NASA's Perseverance rover

Obstacles Detection and Feature Segmentation on Lunar Surface

How will this course help you?



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Problem Formulation

- Goal - Rocks Detection on Lunar Surface with Image Segmentation
- Core technologies - Python, OpenCV, Keras, Tensorflow, Django

Steps-

1. Understanding the basics
2. Getting Familiar with data
3. Understanding the technologies
4. Build, Check, Fine-tune and again Build
5. Application Development

What we will cover in this project?

1. Problem formulation
2. Python Programming Basics
3. Image data analysis and processing
4. Machine Learning (Theory and implementation)
5. Fine-tuning and Optimization
6. Deployment and designing GUI
7. Use-cases and Research Paper
8. Conclusion, Results and Further Opportunities

Your Program Structure

Whole Training Program is divided in 8 Weeks/Modules

Each Module consist of Live sessions, practical code implementation sessions and assignments.

Through each module, performance of participant will be evaluated that will reflect in final performance reports.

Expected Schedule

Even if you miss any live session, video recordings of all sessions will be provided for life-time.

- Session 1: Monday (6 pm - 7 pm) (Assignments)
- Session 2: Wednesday (6 pm - 7 pm)
- Session 3: Friday (6 pm - 7 pm)
- Doubt sessions: Monday-Saturday (7 pm)
- Saturday: Weekly Assignment Submission Day
- We may schedule some guest lectures or fun activities on Sundays

Advice for the further progress in the project-

- Clear your fundamentals before it’s too late
- Try reading and going through all the suggested resources
- Complete your assignments, please
- Attend as many live sessions as possible
- Document everything for your own good
- Discuss ideas with other, but don’t share you whole solutions
- Trying developing new and creative ideas
- **Don’t be afraid to think outside the box**

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Progress and Performance Measures

- Your solutions in the Assignments
- Creativity of the approach
- Code (Clear and Documented)
- Your Behaviour and Discipline in sessions and workspace

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All the Best!