Unit 4

Robot Vision System

* **Robot Vision System :-**

- Robotic vision is defined as the process of extracting, characterizing and interpreting information From image of 3-dimensional world.

- It also termed as computer vision or micro-controll vision which is important sensor technology with a potential application in various industrial operations.

- The basic purpose of robot vision system is to identify an object and determine its location related to the position and orientation.

- The vision system must be capable of handling a multiple views to deal with multiple operations.

- This system must be able to work in industrial env--ironment including lighting and be insensitive to normal light variations.

o **Functions of Robot Vision System :-**

- The operation of robot vision system consist of 3 functions..

1) Sensing
2) Digitization
3) Image processing and analysis

- The image processing further sub divided into pre-processing, segmentation, description, recognition and interpretation.

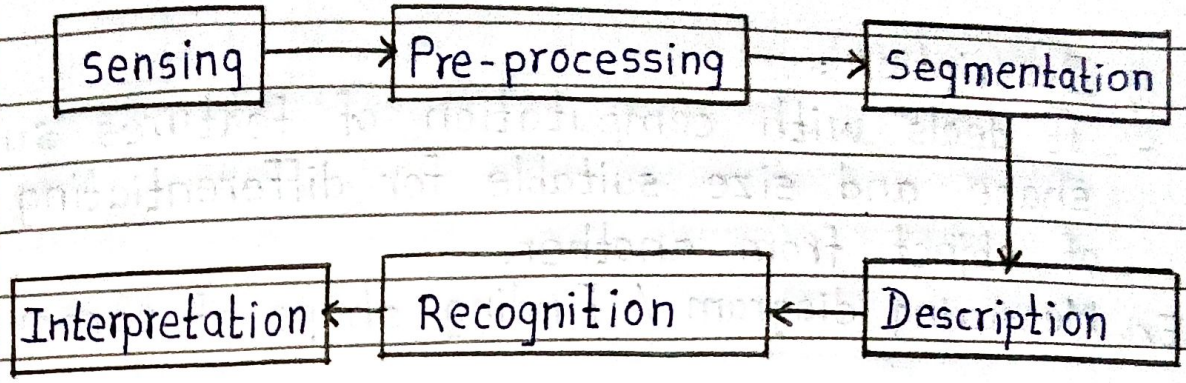

fig: Image Processing

1) Sensing :-

- Sensing is the process that field a visual images of sufficient contrast.
- It is the first step where camera or sensors capturing of object.

Ex:- Camera takes picture on conveyor belt.

2) Pre-Processing :-

- It deals with techniques such as noise reduct^{n} and detail clarity enhancement.
- Pre-processing improves image quality, so it's easier to analyze.

Ex:- Clearing up blurry or dark images before further processing

3) Segmentation :-

- It deals with dividing an image into parts called as segment.
- It is most important because it is inefficient to process a whole image.
- Segmentation separates object from the background

Ex:- Separating screw from conveyor belt background in image.

4) Description :-

- It deals with computation of features such as a shape and size suitable for differentiating one type of object from another.

Ex:- Measuring diagram / Finding shape of screw

5) Recognition :-

- It is the process of identifying, labeling or define the objects: such as bold, book, clock etc.

Ex:- Recognition that object is screw "not null".

6) Interpretation :-

- It assign meaning to recognize the object into a scene. The gap of items viewed as whole rather than individual.
- Finally system understands scene and decide what action to take.

Ex:- Robot decides to pick up the screw and place it in box.

* Components of Vision System :-

- A complete vision system consist of hardware and software for performing a functions of sensing and processing image and utilizing the result obtained to command the robot.
- Robot vision enables the robot to persue it's surrounding using a visual sensors like camera, depth sensor etc.

- The robot interpret this visual information to perform task such as navigation, manipulation, object recognition and inspection.

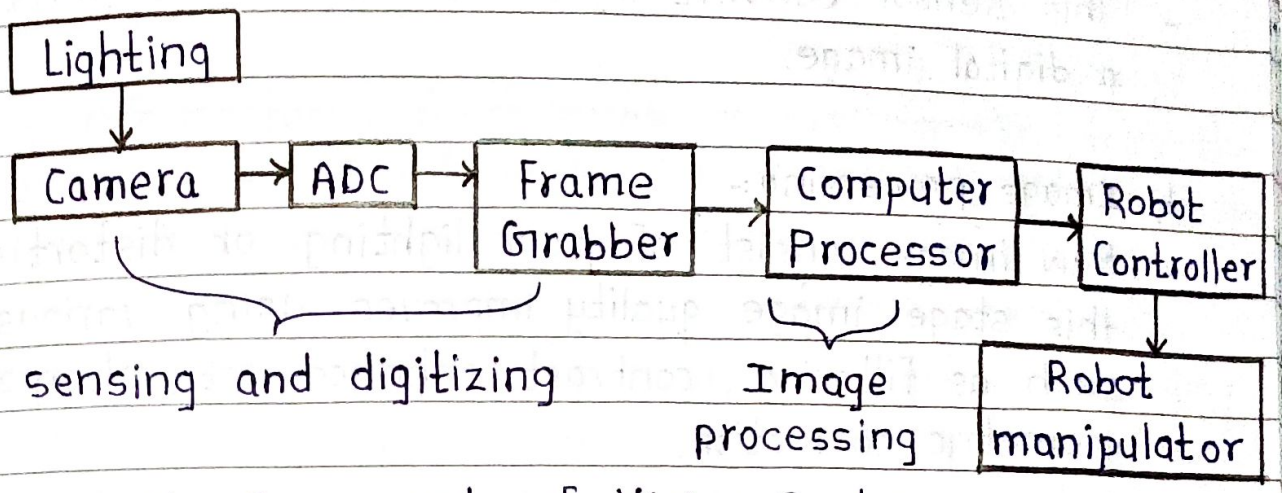

Fig: Components of Vision System

- The vision processing is divided into 2 main levels.
1) Low level vision system (basic)
2) High Level vision system (advance)

1) Low Level Vision System:-

- It is the first step of visual data processing in robotics system.

- It deals with direct extraction of information from raw sensor input.

- This stage doesn't involve understanding the obj. It only focus on detecting features like colour, size, texture, shape of the object.

- The main function of low level vision are as follow:

a) Image acquisition:-

- In this stage the image is captured using vision sensor.
- This sensor convert light into electric signals to form a digital image.

b) Image processing:-

- Raw image consist of poor lighting or distortion. In al this stage image quality improves using various technique such as filtering, contrast enhancement, sharpening and geometric correction.

iii) Edge detection:-

It detects the boundaries of an object in the image by finding the changes in the pixel intensity.

- Purpose of Low Level vision:-

1) It convert raw image data into useful Feature data.
2) It reduce data complexity while preserving essential visual information.
3) This low level vision output serve as input For high level vision.

- Example:-

A robot equiped with camera Feature, captures an image of production line conveyor belt. The low level vision system process the image to detect the object, edges, shapes and location but does not understand what those objects are?

2) High Level Vision System :-

- It represents an intelligent and interpreduced stage of robot vision system.

- In this system, robot analyze and understands the processed visual information to recognize that objects, interpret scene and makes decision.

- It involves patterned recognition, machine learning and reasoning to connect visual data with meaningful decision.

- The main function of high level vision system are as follows:

a) Object Recognition and Classification :-

- It uses the extracted Features from low level stage to identify objects.
- The various technique are used such as tempelate matching, ML, deep learning algorithm.

b) Scene understanding :-

Robot interpret the entire visual scene by the recognizing environment type (office, workshop, kitchen) and understand the special relationship between the objects.

c) Object tracking :-

Once the object is recognized, the system continuously monitors its movements across the frames

For that various techniques are used such as a kalman filter optical Flow or deep learning based trackers.

d) Posed Estimation :-

It determine position and orientation of object. It is essential for robot manipulator, grasping or navigation purpose.

e) Decision Making and Control :-

- Based on recognized object and environment, the robot decides what actions to be performed (pick, move or avoid) or how to execute the task safely and efficiently.
- The high level vision interact with AI and control system to implement decision.

• Purpose of High Level vision system :-

1) It interpret and give meaning to the Feature detected easier.
2) It enables the robots to perform intelligent actions like navigation, inspection or human interaction.

• Example :-

In this stage robot identify the objects and also interpret as a bottle and distinguish from another box. It calculate position and orientation of the bottle. Robot will decide to grasp the bottle and place in packaging area.

* Lagrange's Analysis of Manipulator and Component

- Lagrange's analysis is a mathematical framework used to describe the motion of mechanical syste

- It is based on the concept of energy where the system's behaviour is defined by quantity know as lagrangian which is the difference between system kinetic energy (related to its motion) and potential energy (related to its positions within a forced field)

- When it is applied to robotics manipulator which is multi-tasking system having a multiple joints & links.

- Lagrange's analysis helps in understanding their motion and dynamic.

- Lagrange's analysis performs with the series of following process:

1) Kinetics energy And potential energy formulations
2) Generalized Co-ordinates
3) Lagrangian equation Formation
4) Lagrangian equation of motion analysis
5) Control and analysis

- This method starts by determining the kinetics & potential energy of each individual link in the manipulator.

- The kinetic energy accounts for the motion of each link while potential energy consider the effect of gravity or other external forces acting on the system.

- The system configuration is described using generalized co-ordinates which are variables that uniquely define the system state.

- For a robotic manipulator, this could be a joined angle or displacement that define the positions of each link.

- The lagrangian is formulated as the difference between the system kinetic and potential energy.

- It is the function of the generalized coordinates and their derivatives with respect to time.

- Using lagrangian the eqⁿ of motion For manipulators are derived. These eqⁿ describes how generalized Co-ordinates changes over time and provide a complete description of the system dynamics.

- Once the equation of motion established. They can be used for controlling purpose such as designing controllers to achieved desired movements or an analysing manipulators behaviour under the different condition of load and constraint.

- Lagrange's approaches offers a powerful as well as systematic way to model the dynamics of the robotics manipulator.

- Using this method, engineers and researchers can predict and control the behaviour of this system to accurately.

* Industrial application of vision control robotics system :-

The effective use of robotics system makes assembly, quality control and classification task by using a single camera. It is possible to track the multiple object usually clustered environment. A robot vision control system can be deployed for number of applications in industry.

1) To detect the presence or absence of an objects
2) To locate a position of an object
3) For object identification
4) For pick and place operations
5) For visual inspection
6) For visual guidance

o Advantages of Vision Control Robotics Systems :-

1) It have high flexibility
2) It have great consistency.
3) It is cost effective.
4) It has high precision.

* Applications of Machine Vision :-

1) Industrial manufacturer on large scale.
2) Manufacturing of short run unique object.
3) For retail automation.
4) Quality control and refinement of Food product.
5) Monitoring of agriculture production.
6) Vehicle remote examination and procedure.
7) Medical imaging process.
8) Safety system in industrial environment.
9) Automated monitoring of sites for security & safety
10) Consumer equipment control.
11) Inspection of pre-manufactured object.
12) Control of Automated Guided Vehicle (AGV).

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Unit 5

Robot Programming

* Robot programming:-
It is defineing of desired motion so that the robot may perform them without human intervention.

. Methods of Robot programming:-
Robot programming broadly classified as online and offline programming. Online program consist of teach pendant and lead through programming where as offline programming consist of robot program languages and task level programming.

. Use of teach pendant:-
It is hand held device with no. of switc used to control robot motion. The end point are recorded in controller memory which sequentially played back to execute robot action. The tragitory control by robot controll It is suitable for point to point control application.

. Lead through programming:-
It lead the robot through required sense of motion. The trajectory & end point are recorded using sampling routine which record the point at 62 to 80 times a second when it played back results in smooth continuous motion. It require a large memory.

• OFFline programming :-

In this case program can be developed without using robot. The sequence of operation and robot movement can be optimized and easily improved. The external sensor data can be incorporated through this typically makes the program more complicated which is difficu to modify and maintain.

The existing cad data can be incorporat the dimension of the part & geometric relatn Here the program can be tested and evalu-ated using simulation technique. Here the program can easily maintained or modified

* Robot program as a path in space :-

Robot perform their action by tracing th points (co-ordinates) in 3-dimension eny. The locus of such point along the path defines the sequence of position through whic robot will move its wrist. In most applicatn the end effector is attached to the wrist of robot and program can be consider to be the path of space through which the end effector is to be move by the robot. Since, the robot consist of several joints which linked together definition of path in space required that robot move its access through various position in order to follow back path.

- There are 4 basic robot configuration such as cylinderical, polar, cartesian and joint arm. Each one has 3-access associated with the arm and body configuration along with 2-3 additional joint associated with wrist. The arm and body joints determined the general position in space of end effector. And finally wrist determine its orientation to perform desired task.