Unit 6

* Robot Programming methods:
It involves instructing robots to perform tasks weather through direct controls, algorithms or artifical intelligance. The methods of programming depends on complexity of tasks, the robot's capabilities and the environment in which its operates.

Methods:

(1) Teach Pendant Programming: A teach pendant is a handheld device used by an operator to manually guide the robot through a series of movements and teach it the position of the task. It application are: Assembly lines, material handling.

Advantages:
→ Simple and intuitive, espically for simple tasks.
→ Useful for application where robots movements are fixed and donot require adaption.

(2) Offline Programming: It involves creating robot programs using specialized software on a computer before transferring them to the robot for execution. application are Industrial robots.

Advantages:
→ Reduce downtime
→ Allows for testing in a visual environment before actual deployment.

(4) Text-based Programming: Robots are programmed using a traditional programming language such as C/C++ python, etc. Application are complex robotics task, autonomous robots, mobile robots.

Advantages:
→ highly flexible and customizable.
→ can be integrated with external system and technologies.

(4) learning from Demonstration: A Robot learns tasks by observing human demonstration. The robot is programmed to replicate or generalize the ~~environment~~ movements it observes. Applications are Service robots, medical robots.

Advantages:
→ Reduces the need for explicit programming.
→ The robot can adapt complex, variable tasks.

(5) Behaviour based Programming: The robots control system is divided into a set of behaviours, each responsible for a specific task. Applications are robots working in unstructured environment.

Advantages:
→ Reactive and adaptable to dynamic environment
→ Allows robots to ~~acts~~ handle unexpected changes in real times.

* Robot-Programming languages: These are specialized languages designed to control the behaviour and tasks of robots. These languages are often provide syntax and libraries that simplify the process of programming robots to perform specific action such as movement, sensor reading.

(1) ROS (Robot Operating System) :
It is a flexible framwork for writing robot software and provides libraries and tools to help developers build robot application. It supports various languages programming language but most commonly, python and C++ are used. Application are drones, industrial robots.

(2) VPL (Visual Programming language) : These are graphical programming where developers create programs by manipulating visual elements rather than writing code. Tools used such as blockly, labVIEW, etc. Applications are beginner programming, educational robot.

(3) Python : It is one of the most popular general purpose programming language and is widely used in robots due to its simplicity, extensive libraries, and ease of integration with other systems. Application are libraries such as pytorch, Tenserflow, Robot OS, Automation.

(4) RAPID : It is the proprietary language for programming ABB robots. It is a high level language that allows the control of industrial robots in various application such as welding, assembly and material handling.

(5) Java : It is high-level, OOP language used for developing application for robot control. Java is often used for mobile robots, espically those requiring a portable, cross-plateform solution. Applications are Mobile robots, Android-based Robotics.

⑥ MATLAB / Simulink : They are widely used in academics and industrial research in developing algorithms, simulations and control system. They provide high-level environment for designing and simulation robotic systems, espically in the field of control and signal processing.

⑦ KRL (kuka Robot language) : It is the proprietary language for kuka robots and is used for tasks such as controlling robotic arms and other robotics system. It is similar to structured programming language, with syntax that is similar to C. Applications are manufacturing, packing, welding, assembly tasks., industrial automation.

* Training of Vision System:
It involves the process of teaching the system to recognize and interpret visual data from its environment, typically using a combination of hardware and software. The goal is to enable robots to understand and make decisions based on visual input, wheather it is for object detection, localization, navigation or interaction.

1. Data Collection and Preprocessing
2. Feature Extraction
3. Training the Model
4. Transfer learning
5. Testing and evaluation
6. Integration with robot control system
7. Continuous learning and Improvement.

* Features Extraction:
It the process of identifying and extraction relevant attributes of characteristics from raw data to represent the data efficiently for analysis or processing. It simplies the dataset by reducing dimensionality and focusing on the most informative parts, making its crucial for tasks like classification, clustering or regression.

Why?
→ dimensionality Reduction: Simplifies data to improve computation efficiency and reduce storage.
→ Improves Model Performance: Extracted features highlight important patterns, improving model accuracy.
→ Handles Noise: Remove irrelevant or redundant data, making analysis more robust.

challenges :

→ Curse of dimensionality : Too many features can lead to overfitting.

→ Noisy features : Irrelevant features may reduces model performance.

→ Computational Complexity : high-dimensional data requires significant processing power.

Techniques of Features Extraction :

(1) Statistical Features → Extract numerical summaries that represent the data. Examples : Mean, Variance
Application : Signal Processing, time-series analysis.

(2) Feature Extraction for signal : Extracts relevant information from time-series or other signal data.
- (a) Fourier Transform.
- (b) Wavelet Transform
- (c) Autoregressive coefficients

} Application : Speech analysis, Audio analysis, Fault detection.

(3) Feature Extraction for Text : Converts Unstructured text data into numerical representations.
- (a) Bag of words.
- (b) Word Embedding

Application : Sentiment analysis, topic Modelling.

(4) Feature Extraction for Tabular data : Extracts meaningful features from structured data
- (a) Polynomial Features
- (b) Dimensionality Reduction

(5) Deep learning based technique : Extracts high-level features automatically using neural networks.
application : recommendation system, Autonomous driving

* Image Reduction :

It refers to the process of decreasing the size of an image, either in terms of resolution or file size. This is commonly done to optimize storage, transmission or processing without significantly compromising image quality.

Why ?

→ Storage optimization : Smaller images save disk space.

→ Faster Transmission : Reduced size allows quicker upload/download speeds.

→ Real - time Processing : Lower resolution images are easier to handle in real time application like robotics or web streaming.

→ Compatibility : Smaller images are more compatible with devices or systems with limited resources.

Technique :

(1) Spatial Resolution Reduction : Reducing the number of pixels in the image while maintaining aspect ratio. Technique includes downsampling, Gaussian Pyramid. Application are real time image processing, thumbnail generation.

(2) Compression - based Reduction : Reducing the file size by encoding the image more efficiently, sometimes at the cost of quality. Technique includes lossless compression, lossy compression.

lossless compression : reduces file size without loosing any data

lossy compression : discards less noticable data to achieve higher compression.

(3) Color-Depth Reduction: Reduction the number of bits used to represent color information in an image. Technique are (a) convert from 24 bit to 8 bit (b) Apply dithering to simulate color using fewer bits. Applications simple icons or illustrations.

(4) Region-of-Interest Reduction: Focusing on the important part of an image and cropping or discarding the rest. Technique includes manual cropping, face detection algorithm. Applications are profile pictures, product images.

(5) Frequency Domain Reduction: Reducing an image by manipulating its frequency representation. Technique included discrete cosine Transform, wavelet transform. Application are advanced compression methods.

(6) Superpixel Reduction: Grouping similar pixels into superpixels to reduce complexity while preserving structure. Technique includes SLIC. Applications are preprocessing for machine learning.

Consideration:
(1) Quality Vs Size trade-off
(2) ~~Pos~~ Preservation of features
(3) Use case: choose reduction technique.

* Segmentation: It is the process of dividing a digital image into regions or ~~segment~~ Segments. The goal is to simplify or transform the image into a more manageable form for analysis such as identifying objects,

boundaries or areas of interest.

Why ?

(1) Object detection : Isolating objects of interest from the background.

(2) Scene Understanding : Identifying and labelling different components of a scene.

(3) Medical Imaging : Detection anomalies in X-rays, MRI or CT scans.

(4) Autonomous Vehicles : Recognizing road boundaries, obstacles and pedestrians.

Types :

(1) Thresholding - based Segmentation : divides the images by applying a threshold value to pixels intensity.
Application : Simple images with clear intensity contrasts like document scanning.

(2) Edge - based Segmentation : detects edge (sudden changes in intensity) to outline object boundaries. Applications are finding outlines of object in images.

(3) Region based Segmentation : Groups neighbouring pixels with similar properties. Applications are segmenting homogeneous region like sky, water or terrain.

(4) clustering based Segmentation : Uses algorithms to group pixels based on features like color, intensity or texture. Applications are segmenting multicolor images.

(5) Deep - learning based Segmentation : Utilizes Convolutional neural network (CNNs) for pixel - wise segmentation.

Applications are high accuracy application like facial recognition.

challenges:

1. Illumination Variance : Inconsistent lightening effects.
2. Noise and Artifacts : Sensor noise can obscure details
3. Overlapping Objects : difficult to differentiate closly packed or touching objects.
4. Complex Scenes : high Variability in colors, texture, shapes. Compliates segmentation.

* Pixelation: It refers to the representation of an image using a grid of small, Square units called pixcals. Each pixels represents a single point of color or intensity in the image.

Causes:

1. low Image Resolution
2. Image Compression
3. Zooming or scaling
4. Rendering or Encoding Issue
5. Sensor limitations

Effects:

1. Reduced Visual Quality
2. loss of detail
3. Artifacts.

Application:

1. Privacy Protection
2. Artistic Effects.

Minimize:

1. Capture at higher Resolution
2. Use appropriate display device
3. Avoid Overcompression
4. Use Image Processing.

* Color Encoding :

It refers to the process of representing colors numerically in a form that computers and vision systems can process. Colors are typically encoded in a digital format using various color models and encoding schema.

Color Models:

1. RGB
2. HSV
3. YUV
4. Grayscale

Color Encoding Technique:

1. Bit depth
2. Indexed color
3. color Quantization
4. color coding

Application :

1. object detection
2. Path navigation
3. Scene Understanding
4. Sorting and classification

Challenges:

1. lighting Variations : changes in illumination can affect color perception.
2. color Ambiguity : similar color can be difficult to distinguish in certain models.
3. camera limitations : low-resolution cameras may inaccurately capture color.