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Artificial Intelligence for Engineering

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UNIT 5:

5.1 Image and Face Recognition

Image Recognition

- Image recognition refers to technology of AI that identify places, logos, people, objects, buildings, and several other variables in images.
- Image recognition is a part of computer vision and a process to identify and detect an object or attribute in a digital video or image.
- The best example of image recognition solutions is the face recognition – say, to unlock your smartphone you have to let it scan your face.

Modes and types of image recognition

We can break image recognition into two separate problems: single and multiclass recognition.

- In single class image recognition, models predict only one label per image.
- In cases where only two classes are involved (dog; no dog), we refer to these models as binary classifiers.
- Multiclass recognition models can assign several labels to an image.

Working of Image Recognition

1. We need a dataset containing images with their respective labels. For example, an image of a dog must be labelled as a dog or something that we can understand.
2. Next, these images are to be fed into a convolutional Neural Network and then trained on them. These networks consist of convolutional layers and pooling layers in addition to Multiperceptron layers (MLP).
3. We feed in the image that is not in the training set and get predictions.

Uses of Image Recognition

1. **Drones:** Drones equipped with image recognition capabilities can provide vision-based automatic monitoring, inspection, and control of the assets located in remote areas.
2. **Manufacturing:** Inspecting production lines, evaluating critical points on a regular basis within the premises. Monitoring the quality of the final products to reduce the defects.
3. **Forest Activities:** Drones can monitor the

forest, predict changes that can result in forest fires, and prevent poaching.

4. **Autonomous vehicles:** Autonomous vehicles with image recognition can identify activities on the road and take necessary actions. Mini robots can help logistics industries to locate and transfer the objects from one place to another.

5. **Military Surveillance:** Detection of unusual activities in the border areas and automatic decision-making capabilities can help prevent infiltration and result in saving the lives of soldiers.

6. **Face Recognition:** Face recognition is a method of identifying or verifying the identity of an individual using their face. Face recognition systems can be used to identify people in photos, video, or in real- time.

Working of Face Recognition

The stepwise method is as follows:

1. **Face Detection:** To begin with, the camera will detect and recognize a face. The face can be best detected when the person is looking directly at the camera as it makes it easy for facial recognition.

2. **Face Analysis:** Then the photo of the face is captured and analysed. Most facial recognition relies on 2D images rather than 3D because it is more convenient to match to the database.

3. **Image to Data mathematical Conversion**: Now it is converted to a Formula and these facial features become numbers. This numerical code is known a face print. As every person has a unique fingerprint, in the same way, they have unique face print.

4. **Match Finding:** Then the code is

compared against a database of other face prints. This database has photos with identification that be compared. The technology then identifies a match for your exact features in the provided can database

Face Recognition Softwares :

1. **Deep Vision AI:** Deep Vision AI is a front runner company excelling in facial recognition software. The company owns the proprietorship of advanced computer vision technology that can understand images and videos automatically. It then turns the visual content into real-time analytics and provides very valuable insights.

2. **SenseTime:** The technology offered by Sense Time is multifunctional. The aspects of this technology are expanding and include the Capabilities of Facial recognition, Image recognition, intelligent video analytics, autonomous driving, and medical image recognition.

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3. **Amazon Rekognition:** This solution allows an easy method add image and video analysis to various applications. It uses a highly scalable and proven deep learning technology.
4. **FaceFirst:** FaceFirst is secure, accurate, private, fast, and scalable included for software. Plug-and-play solutions are also included for physical security, authentication of identity, access control, and visitor analytics.

Applications of Face Recognition:

1. **Genetic Disorder Identification:** There are healthcare apps such as Face2Gene and software like Deep Gestalt that uses facial recognition to detect a genetic disorder. This face is then analyzed and matched with the existing database of disorders.
2. **Airline Industry:** Some airlines use facial recognition to identify passengers. This face scanner would help saving time and to prevent the hassle of keeping track of a ticket.
3. **Hospital Security:** Facial recognition can be used in hospitals to keep a record of the patients that is far better than keeping records and finding their names, address.
4. **Detection of emotions and sentiments**: It can be used to detect emotions which patients exhibit during their stay in the hospital and analyze the data to determine how they are feeling.

Problems and Challenges

The face recognition technology is facing several challenges.

1. **Pose:** A Face Recognition System can tolerate cases with small rotation angles, but it becomes difficult to detect if the angle would be large.
2. **Expressions:** Because of the emotions, human mood varies and results in different expressions. With these facial expressions, the machine could make mistakes to find the correct person identity.
3. **Aging:** With time and age face changes it is unique and does not remain rigid due to which it may be difficult to identify a person who is now 60 years old.
4. **Identify similar faces:** Different persons may have a similar appearance that sometimes makes it impossible to distinguish.

Disadvantages of Face Recognition
1. Danger of automated blanket surveillance.
2. Lack of clear legal or regulatory framework.
3. Violation of the principles of necessity and proportionality.
4. Violation of the right to privacy.

5.2 Object Recognition

- Object recognition is the area of artificial intelligence (AI) concerned with the abilities of robots and other AI implementations to recognize various things and entities.
- Object recognition allows robots and AI programs to pick out and identify objects from inputs like video and still camera images.
- Object recognition is at the convergence points of robotics, machine vision, neural networks and AI. Google and Microsoft are among the companies working in the area - Google's driverless car and Microsoft's Kinect system both use object recognition.
- Object recognition consists of recognizing, identifying, and locating objects within a picture with a given degree of confidence.
- In this process, the four main tasks are:
  1. Classification & Tagging.
  2. Detection & Segmentation.

1. Classification and tagging

An important task in object recognition is to identify what is in the image and with what level of confidence. While classification recognizes only one class of objects, tagging can recognize multiple ones for a given image.

2.Detection and segmentation

Once identified what is in the image, we want to locate the objects. There are two ways to do so: detection and segmentation. Detection outputs a rectangle, also called bounding box, where the objects are. segmentation identifies the objects for each pixel in the image,

resulting in a very precise map.

5.3 Speech Recognition

Speech recognition is the process that enables a computer to recognize and respond to spoken words and then converting them in a format that the machine understands.

Example: Voice Typing in GBaord and other transcription programs use speech recognition to convert your spoken words into text while digital assistants like Siri and Alexa respond in text format or voice.

Speech recognition focuses on the translation of speech from a verbal format to a text one whereas **voice recognition** just seeks to identify an individual's voice.

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Why do we need Speech Recognition?

✔ Most natural form of communication.

✔ Differently abled people can use it with ease.

✔ Helps people who can't read or write, Hence they can communicate with computers normally.

✔ Increase adaption of technology by making it easier to use.

Types of Speech Recognition

There are three types of speech recognition.

1. **Speaker Dependent:** software works by learning the unique characteristics of a single person's voice, in a way similar to voice recognition. New users must first "train" the software by speaking to it, so the computer can analyze how the person talks.

2. **Speaker Independent:** software is designed to recognize anyone's voice, so no training is involved. This means it is the only real option for applications such as interactive voice response systems. Hence it's mostly voice recognition along with speech recognition.

3. **Speaker Adaptive:** They usually begins as a speaker independent model and slowly adapts and adjusts to the individual using the systems. Virtual Assistants like, Google, Alexa, Siri etc. uses similar methods.

Applications of Speech Recognition:

1. **Voice to text:** Speech recognition enables hands free computing. Users don't need to type emails, reports, and other documents.

2. **Voice commands to smart home devices:** Smart home applications are mostly designed to take a certain action after the user gives voice commands.

3. **Security**: As technology integrates into our daily lives, security protocols are an increasing priority. Voice-based authentication adds a viable level of security.

4. **Voice Search:** This is the most common use of speech recognition. Users prefer to use voice searches Siri and Google voice search, over the traditional method of typing.

5. **Automotive**: In-car speech recognition systems, aim to remove the distraction of looking down at your mobile phone while you drive. Drivers can use simple voice commands to initiate phone calls, select radio stations or play music.

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5.4 Computer Vision (CV)

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.

One of the driving factors behind the growth of computer vision is the amount of data we generate today that is then used to train and make computer vision better.

Hardware of Computer Vision System

1. Power supply
2. Image acquisition device such as camera
3. A processor
4. A software
5. A display device for monitoring the system
6. Accessories such as camera stands, cables, and connectors

Computer Vision tasks:

1. **Object Detection** is the ability to detect or identify objects in any given image correctly along with their spatial position in the given image, in the form of rectangular boxes (known as Bounding Boxes) which bound the object within it.

2. **Image Classification** basically means identifying what class the object belongs to. For example there are objects present belonging to various classes such as trees, huts, giraffe, etc. The machine or deep learning model would determine that the animal detected in the image belongs to class giraffe with the highest probability.

3. **Image Captioning** is looking at an image and describing what is happening in the image. The image contains annotations or labels which describe what is happening in the Image which should give you a good idea about what Image Captioning does.

4. **Image Reconstruction or Image Inpainting** is the ability to identify what is missing in an image in order to reconstruct it.

5. **Face recognition** is identifying or verifying the identity of an individual using their face. Face recognition systems can be used to identify people in photos, video, or in real-time.

6. **Semantic Segmentation** basically tries to identify similar objects in the object which belong to the same class at the pixel Level.

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Applications of Computer Vision

1. **Self-Driving Cars:** Computer vision enables self- driving cars to make sense of their surroundings. Cameras capture video from different angles around the car and feed it to computer vision software to find the extremities of roads, read traffic signs, detect other cars, objects and pedestrians.

2. **CV In Facial Recognition:** Computer vision also plays an important role in facial recognition applications, the technology that enables computers to match images of people's faces to their identities. Computer vision algorithms detect facial features in images and compare them with databases of face profiles.

3. **CV In Augmented Reality & Mixed Reality** Computer vision also plays an important role in augmented and mixed reality, the technology that enables computing devices such as smartphones, tablets and smart glasses to overlay and embed virtual objects on real world imagery.

4. **CV In Healthcare** Computer vision has also been an important part of advances in health-tech. Computer vision algorithms can help automate tasks such as detecting cancerous moles in skin images or finding symptoms in x-ray and MRI scans.

5. More from the Applications of Object, Image and Face Recognition.

5.5 Robots & Robotics

Robots are artificial agents working in real world environment. Robots are aimed at manipulating the objects by perceiving, picking, moving, modifying the physical properties of object.

Components of a Robot

1. **Power Supply :** The robots are powered by batteries, solar power, hydraulic, or pneumatic power sources.

2. **Actuators :** They convert energy into movement.

3. **Electric motors (AC/DC):** They are required for rotational movement.

4. **Pneumatic Air Muscles :** They contract when air is sucked in them.

5. **Muscle Wires :** They contract by only 5% when electric current is passed through them.

6. **Piezo Motors and Ultrasonic Motors** : Best for industrial robots.

7. **Sensors :** They provide knowledge of real time information on the task environment. They are equipped with vision sensors to be to compute the depth in the environment.

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Robot Locomotion

Locomotion is the mechanism that makes a robot capable of moving in its environment. There are various types of locomotions -

1. **Legged Locomotion:** This type of locomotion consumes more power while demonstrating walk, jump, trot, hop, climb up or down, etc

2. **Wheeled Locomotion:** It requires fewer number of motors to accomplish a movement. It is little easy to implement as there are less stability issues in case of more number of wheels. It is power efficient as compared to legged locomotion.

3. **Slip/Skid Locomotion:** In this type, the vehicles use tracks as in a tank. The robot is steered by moving the tracks with different speeds in the same or opposite direction. It offers stability because of large contact area of track and ground.

Robotics

Robotics is a domain in artificial intelligence that deals with the study of creating intelligent and efficient robots. Aspects of Robotics:

1. The robots have mechanical construction, form, or shape designed to accomplish a particular task.

2. They have electrical components which power and control the machinery.

3. They contain some level of computer program that determines what, when and how a robot does something.

Applications of Robotics

The robotics has been used in the various fields:

1. **Industries**: Robots are used for handling material, cutting, welding, drilling, polishing.

2. **Military:** Autonomous robots can reach inaccessible and hazardous zones during war.

3. **Medicine:** The robots are capable of carrying out hundreds of Clinical tests simultaneously, rehabilitating permanently disabled people, and performing complex Surgeries

4. **Entertainment:** Disney's engineers have created hundreds of robots for movie making.

5. **Space Exploration:** There are many things in space that are very dangerous for astronauts to do. Robots are a great choice because there are no chances for the loss of human life then.

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