Applications of computer vision in real-world problems

- Optical character recognition (OCR): reading handwritten postal codes on letters and automatic number plate recognition (APNR). Also used:
  - in translating foreign signages to different language.
  - Identifying mathematical equations and solve it.
- Machine inspection: rapid parts inspection for quality assurance using stereo vision with specialized illumination to measure tolerances on aircraft wings or auto body parts or looking for defects in steel castings using X-ray vision.
  - Commonly used in manufacturing to check for defects.
- Retail - automated checkout lanes for a cashier-less experience.
  - Identifying products and checks database for their price.
- 3D model building (photogrammetry): fully automated construction of 3D models from aerial photographs used in systems such as Bing Maps. Commonly used with drones.
- Medical imaging: registering pre-operative and intra-operative imagery or performing long-term studies of people's brain morphology as they age;
- Automotive safety: detecting unexpected obstacles such as pedestrians on the street, under conditions where active vision techniques such as radar or lidar do not work well. Used in SD Cars
- Motion capture (mocap): using retro-reflective markers viewed from multiple cameras or other vision-based techniques to capture actors for computer animation. Used in movies requiring advanced visual effects.
- Surveillance: monitoring for intruders, analyzing highway traffic, and monitoring pools for drowning victims. Also used in airports using face recognition.
- Fingerprint recognition and biometrics: for automatic access authentication as well as forensic applications. Modern phones nowadays accept fingerprints as authentication credential.

- Exposure bracketing: merging multiple exposures taken under challenging lighting conditions (strong sunlight and shadows) into a single perfectly exposed image.
- Morphing: turning a picture of one of your friends into another, using a seamless morph transition.
- 3D modeling: converting one or more snapshots into a 3D model of the object or person you are photographing.

Basic geometric primitives that describe three-dimensional shapes

- Points - a primitive with no size. It only has a location. In a 3D space, it's defined as: {x, y, z}. In 2D space, it's just {x,y}
- Conics – Curves that arise from the intersection of a plane and a 3D cone. Some of the curves are ellipse, parabola, and hyperbola
- Lines – set of points extending in either direction infinitely. In our above example, it consists of two points.
- Planes – a flat 2-D or 3-D surface that extends infinitely far.

Under Point Operators these are the simplest kind of image processing transformation

This is the simplest kind of image processing transform where manipulation takes place on each pixel rather than considering its neighbors.

a) Pixel Transform - The pixel is the basis of transformation. An image can be represented into a grid with cells containing numbers corresponding their colors. Transformation occurs when each cell's value is changed. See Figure 1. e.g., Brightness and Contrast Adjustments. The general function for image brightness and contrast is:: g(x,y) = αf(x,y) + ß

b) Color Transform – Pixel based operator that involves colors. Transformation occurs when each channel in the Color Model is adjusted. For example, RGB is a color model, and R, G, and B are color channels. You can tweak the value R, and each value R of each cell will be tweaked. Another example of color transformation is negative. It has a function g(x,y) = -1 * f(x,y) + 255 where g(x,y) is the transformed image and f(x,y) is the orginal. This inverses a color intensity.

- Histogram Equalization – This is the process of finding the best values of RGB that would make the desirable appearance of an image. This deals with adjusting the right contrast.

Segmentation Types

a. Local: Concerned with specific region of the image
b. Global: Concerned with segmenting the entire image

Segmentation Techniques

a) Discontinuity Detection - This is a method of segmenting a picture into areas based on discontinuity. This is where edge detection comes in. Discontinuity in edges generated due to intensity is recognized and used to establish area borders. Examples: Histogram filtering and contour detection.

b) Similarity Detection - Similarity Detection: A method of segmenting a picture into sections based on resemblance. Thresholding, area expansion, and region splitting, and merging are all included in this methodology. All of them split the image into sections with comparable pixel counts. Based on established criteria, they divide the picture into a group of clusters with comparable features. Example: Kmeans, Colour detection/classification.

c) Neural Network Approach - For the goal of decision making, neural network-based segmentation algorithms replicate the learning techniques of the human brain. This approach is widely used in segmenting medical images and separate them from the background. A neural network is made up of a vast number of linked nodes, each with its own weight.

Feature-based alignment technique based on Orientation Checker

The problem of estimating the motion between two or more sets of matched 2D or 3D points. See figure 1 for an example of 3D points matched together.

Steps for feature-based alignment

- Read Images
- Detect Features
- Match Features
- Calculate Homography: Consider two images of a plane (top of the book) shown in Figure 3. The red dot represents the same physical point in the two images. In computer vision jargon we call these corresponding points. Figure 1. shows four corresponding points in four different colors — red, green, yellow and orange. A Homography is a transformation (a 3×3 matrix) that maps the points in one image to the corresponding points in the other image.

Feature-based alignment technique based on Panorama

Since we need to detect features, we need a detector and descriptor for it. For this example, we will be using the ORB as it has both. We'll use the steps provide above.

There are two of the many ways that you can use feature-based alignment. First, you can use it to correct an image's orientation relative to the other image based on the matched features for both images. Second, you can extend two images depending on the matched features for both images create a panoramic image.

a) Orientation Checker
- Read Images
- Detect Features
- Match Features
- Calculate Homography, and Aligned

b) Panorama
- Read Images
- Detect Features
- Match Features
- Calculate Homography, Combined to form the Panorama, and Cropped