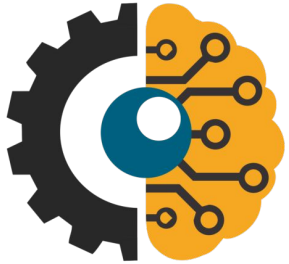


Computer Vision

Introduction

Course / Tutorial Overview

- Basics of Image Processing
  - Color Models
  - Noise and Smoothing
  - Histograms
  - Geometric Operations
- Binary Image Processing
  - Thresholding
  - Mathematical Morphology
  - Connectivity
- 3D Vision
  - Camera Model
  - Epipolar Geometry
- Edge Image Processing
  - Edge Detection
  - Contour Following
  - Hough Transform
- Features
  - Moravec, Harris, FAST
  - SIFT
- Recognition
  - Hough
  - SIFT
  - Template and Chamfer Matching
  - Robust Object Detection

What is Computer Vision?

- Computer Vision is about understanding images
  - Greyscale, Color or Multi-spectral
  - Snapshots or video sequences
  - Static or moving camera
  - Static or dynamic scene
  - Calibrated / un-calibrated camera
- Computer Vision aims to extract useful information from images
  - Inspection purposes
  - Analysis purposes
  - Control purposes

Definitions of Computer Vision

machine vision: A general term for processing image data by a computer and often synonymous with computer vision. There is a slight tendency to use "machine vision" for practical vision systems, such as for industrial vision, and "computer vision" for more exploratory vision systems or for systems that aim at some of the competences of the human vision system. [JKS:1.1]

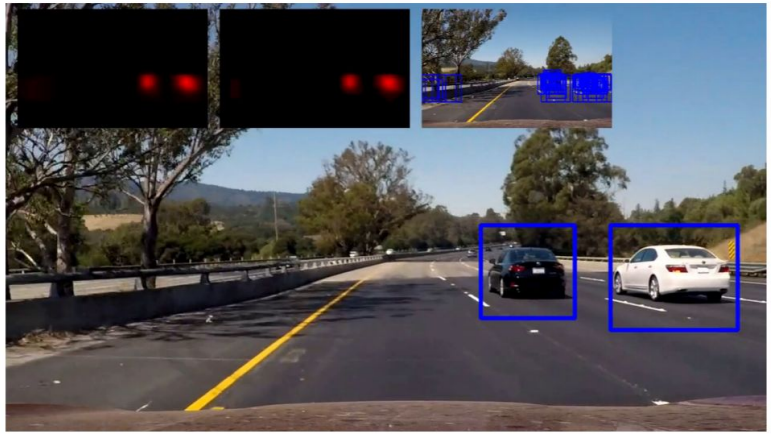
industrial vision: A general term covering uses of machine vision technology to industrial processes. Applications include product inspection, process feedback, part or tool alignment. A large range of lighting and sensing techniques are used. A common feature of industrial vision systems is fast processing rates (*e.g.*, several times a second), which may require limiting the rate at which targets are analyzed or limiting the types of processing.

image analysis: A general term covering all forms of analysis of image data. Generally image analysis operations result in a symbolic description of the image contents. [AJ:1.5]

computer vision: A broad term for the processing of image data. Every professional will have a different definition that distinguishes computer vision from machine vision, image processing or pattern recognition. The boundary is not clear, but the main issues that lead to this term being used are more emphasis on 1) underlying theories of optics, light and surfaces, 2) underlying statistical, property and shape models, 3) theory-based algorithms, as contrasted to commercially exploitable algorithms and 4) issues related to what humans broadly relate to "understanding" as contrasted with "automation". [JKS:1.1]

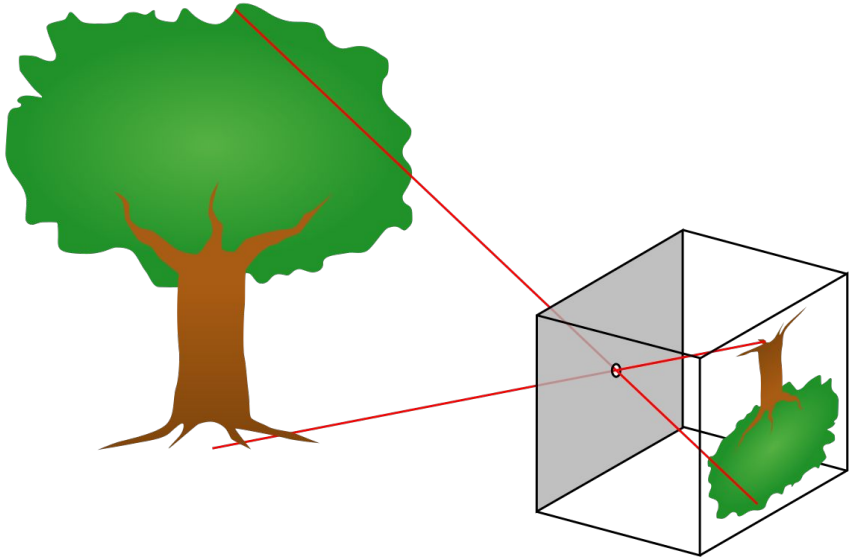
Dawson-Howe et al., Dictionary of Computer Vision & Image Processing

Motivation for Computer Vision



Pinhole Model for Cameras

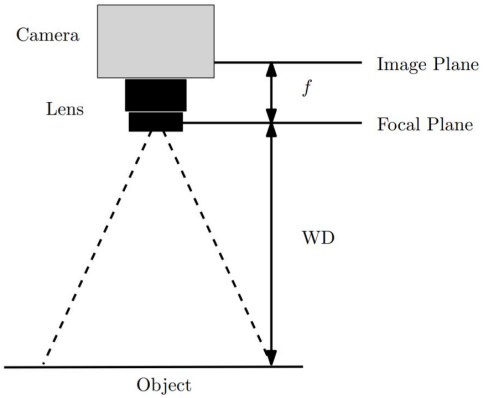
$$\begin{bmatrix} i.w \\ j.w \\ w \end{bmatrix} = \begin{bmatrix} f_i & 0 & c_i \\ 0 & f_j & c_j \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$



- Image Plane
- Focal Length
- Location of the optical centre

Camera Specifications

- Sensor type
  - CMOS/CDD
- Sensor Size
- Resolution (pixels)
- Lens Focal Length (f)
- Lens Aperture Range



$$\text{FOV} = \frac{d \cdot \text{WD}}{f}$$, where d is the sensor size

Images and Pixels

- Continuous 2D Functions
  - (i,j) or (column,row) or (x,y)
- Discrete Representation
  - Sample
  - Quantise
- Number of Samples
  - Wasted time and computation time
- Resolution
  - Quantisation - typically 8 bits

```
cv::Mat image, smaller_image;
cv::resize( image, smaller_image, cv::Size( image1.cols/2, image.rows/2 ));
```

Quantisation - Code Example

```
void ChangeQuantisationGrey( Mat &image, int num_bits )
{
  CV_Assert( (image.type() == CV_8UC1) && (num_bits >= 1) && (num_bits <= 8) );
  uchar mask = 0xFF << (8-num_bits);
  for (int row=0; row < image.rows; row++)
    for (int col=0; col < image.cols; col++)
      image.at<uchar>(row,col) = image.at<uchar>(row,col) & mask;
}
```

Color Models - Color vs Grayscale

- Luminance only
  - Simple representation
  - Humans can understand
- Color images
  - Multiple channels for colors
  - More complex to process
- Different Color Models
  - CMY Images
  - YUV Images
  - HLS Images
  - HSV Images

Typically operations on grayscale and representation on color images