20MCA24C DIGITAL IMAGE PROCESSING
UNIT V - IMAGE PROCESSING with openCV

FACULTY

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UNIT V

Image Processing with Open CV

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Introduction What is Image Processing?„any form of signal processing for which the input isan image; the output of image processing may be either an image or a set of characteristics or parameters related to the image. Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it"

Examples Smoothing

Examples Erosion ↔ Dilation

Examples Edge detection

Examples Hough line transform

Example Face detection

Basic Concepts An image is a matrix

Basic Concepts A colour image has 3 2-d matrices for R, G , B

Basic concepts Example

- Basic operations: Open CV Reading and displaying images
- Basic operations: Open CV Writing images
- Core module: Open CV Accessing individual pixels
- Core module: OpenCV Contrast and Brightness adjustment g(x) = a f(x) + b a = Contrast parameter b = Brightness parameter
- Core module: Open CV Contrast and Brightness example a =2.2 b=50
- Core module: Open CV Drawing functions Lines Circles Ellipse sPolygon
- Image Processing Smoothing – Removes noiseUses filters like Gaussian, Median, Bilateral median Blur (src, dst, i); Gaussian Blur(src, dst, Size(i, i), 0, 0);bilateral Filter (src, dst, i, i*2, i/2);

- Image Processing Smoothing
- Image Processing Erosion and Dilation Used to diminish or accentuate featuresErode + Dilate = Removal of stray marks Erosion erode(src, erosion_dst, element); Dilation dilate (src, dilation_dst, element);
- Image Processing Histogram calculation
- Image Processing Histogram equalisation – Improves contrastcv Equalize Hist(img, out);
- Image Processing Edge detection
- Image Processing Sobel Edge Detector

- Image Processing Laplace Edge Detector
- Image Processing Canny Edge Detector Best edge detector available Uses more advanced intensity gradient based methods
- Feature Detection The following 3 are considered to be keypoints in an image1) Edges2) Corner (also known as interest points)3) Blobs (also known as regions of interest)Once the features have been found, these features are „described". That is, the details around the keypoints are recorded. Later these descriptors are matched against incoming images.
- Feature Detection Feature Extraction: SURF, SIFT, BRIEF Feature Descriptors: SURF, SIFT, BRIEF, STAR Matchers: FLANN, Brute Force

- What is a Colour Space• Color space is a more specific term for a certain combination of a color model plus a mapping function, the term "color space" tends to be used to also identify color models, since identifying a color space automatically identifies the associated color model.
- Colour Space• Gamut + Colour Model = Colour Space• (a colour mapping function + colour model = colour space)
- What is a Gamut• Adding a certain mapping function between the color model and a certain reference color space results in a definite "footprint" within the reference color space.• This "footprint" is known as a gamut, and, in combination with the color model, defines a new color space.
- Gamut• In color theory, the gamut of a device or process is that portion of the color space that can be represented, or reproduced. Generally, the color gamut is specified in the hue– saturation plane, as a system can usually produce colors over a wide intensity range within its color gamut.
- CRT Gamut
- Capturing the Colour Space
- Capturing the Colour Space• Camera Level• The white triangle is what the camera is producing.• Postproduction• black triangle

- It can changes the orientation, size, and shape of the objects in the database as well as on the graphics image, as shown in figure below. This alter the coordinate descriptions of objects. Geometric transformations
- • **Use of Geometric Transformations :-** The geometric transformations are used for the following purposes: i. In a construction of a model; ii. In editing the model using the commands like : translate, rotate, zoom, mirror, array, etc; iii. For obtaining orthographic, isometric and prospective views of the model; iv. To view the model from different positions; and v. In animations.
- Basic geometric transformations : The basic geometric transformations used in modelling are: 1) Translation 2) Rotation 3) Scaling 4) Reflection 5) Shear 6) Concatenated (Composite) Transformation
- Reflections :- These are like mirror images as seen across a line or a point. Translations :- This moves the figure to a new location with no change to the looks of the figure. Rotations :- This turns the figure clockwise or counter-clockwise but doesn’t change the figure.
- TRANSLATION A translation is a transformation that slides a figure across a plane or through space. With translation all points of a figure move the same distance and the same direction.
- Translations If a figure is simply moved to another location without change to its shape or direction, it is called a translation (or slide). If a point is moved “a” units to the right and “b” units up, then the translated point will be at (x + a, y + b). If a point is moved “a” units to the left and “b” units down, then the translated point will be at (x - a, y - b). A B Image A translates to image B by moving to the right 3 units and down 8 units. Example: A (2, 5) □ B (2+3, 5-8) □ B (5, -3)

- What Is Histogram? It is a representation of a frequency distribution by means of rectangles whose widths represent class intervals and whose areas are proportional to the corresponding frequencies. It Looks like
- Mathematical Definition In a more general mathematical sense, a histogram is a function mi that counts the number of observations that fall into each of the disjoint categories (known as bins). let n be the total number of observations and k be the total number of bins, the histogram mi meets the following conditions:
- When Are Histograms Used? Summarize large data sets graphically Compare measurements to specifications Communicate information to the team Assist in decision making
- What are the parts of a Histogram? Histogram is made up of five parts: Title: The title briefly describes the information that is contained in the Histogram. Horizontal or X-Axis: The horizontal or X-axis shows you the scale of values into which the measurements fit. Bars: The bars have two important characteristics—height and width. The height represents the number of times the values within an interval occurred. The width represents the length of the interval covered by the bar. It is the same for all bars.
- Continue. Vertical or Y-Axis: The vertical or Y-axis is the scale that shows you the number of times the values within an interval occurred. The number of times is also referred to as "frequency.“ Legend: The legend provides additional information that documents where the data came from and how the measurements were gathered

- What is Python…? • Python is a general purpose programming language that is often applied in scripting roles. • So, Python is programming language as well as scripting language. • Python is also called as Interpreted language 3
- Differences between program and scripting language Program Scripting • a program is executed (i.e. the source is first compiled, and the result of that compilation is expected) • A "program" in general, is a sequence of instructions written so that a computer can perform certain task. • a script is interpreted • A "script" is code written in a scripting language. A scripting language is nothing but a type of programming language in which we can write code to control another software application. 4

- History • Invented in the Netherlands, early 90s by Guido van Rossum • Python was conceived in the late 1980s and its implementation was started in December 1989 • Guido Van Rossum is fan of ‘Monty Python’s Flying Circus’, this is a famous TV show in Netherlands • Named after Monty Python • Open sourced from the beginning 5
- Why was python created? "My original motivation for creating Python was the perceived need for a higher level language in the Amoeba [Operating Systems] project. I realized that the development of system administration utilities in C was taking too long.
- Moreover, doing these things in the Bourne shell wouldn't work for a variety of reasons. ... So, there was a need for a language that would bridge the gap between C and the shell” –
- Scope of Python • Science - Bioinformatics • System Administration -Unix -Web logic -Web sphere • Web Application Development -CGI -Jython – Servlets • Testing scripts

- What can I do with Python…? • System programming • Graphical User Interface Programming • Internet Scripting • Component Integration • Database Programming • Gaming, Images, XML , Robot and more 9
- Who uses python today… • Python is being applied in real revenue-generating products by real companies. For instance: • Google makes extensive use of Python in its web search system, and employs Python's creator. • Intel, Cisco, Hewlett-Packard, Seagate, Qualcomm, and IBM use Python for hardware testing. • ESRI uses Python as an end-user customization tool for its popular GIS mapping products. • The YouTube video sharing service is largely written in Python 10

Graphical User Interface (GUI)

- Graphical User Interface (GUI) Graphical User Interface (GUI) is a visual way of interacting with the computer using the components like windows, icons, labels, text-boxes, radio buttons, etc. GUI is a program interface that takes the advantage of the computer graphics capabilities to make the program easier to use. A well designed GUI helps the users to get rid from remembering complex commands by presenting command driven graphical layout. GUI uses windows, icons and menus to carry out commands such as opening files, deleting files and moving files. It refers to the graphical interface of a computer that allows users to click and drag objects with a mouse instead of entering text at a command line.
- Frame In graphics and desktop publishing applications, a rectangular area in which text or graphics can appear is termed as a frame. Frames are rectangular areas meant for inserting graphics and text. They allow users to place objects wherever they want to on the page.

Window Window is the total visible screen of any application. It consists of a visual area that contains some of the graphical user interface of the program. A window is framed by a window decoration. It has a rectangular shape that can overlap with the area of other windows. It displays the output and allows input to one or more processes.

- Label A label is a graphical control element, which displays text on a form. It is a static control; having no interactivity. A label is generally used to identify a nearby text box. A label in GUI is just like a piece of paper, polymer, cloth, metal, or other material on a container or product, written or printed information about the product. In computing, labels are used when the texts are written for informational and naming purpose
- Text Box A text box is a graphical control element often appears with a label and is intended to enable the user to input text information used by the program. It is an area where user can input data and information.
- Text Field A text field is a text control GUI element that enables the user to type a small amount of text. When the user indicates that text entry is complete, the text field processes an event.
- Menu Menu is a control that allows the user to select an option out of a list of options. It is a list of options or commands presented to an operator by a computer.
- Buttons Buttons are control which can be clicked upon to select an option from a selection of options. Its name comes from the mechanical push-button group on a car radio receiver.
- Combo Box Combo box is a combination of a single-line text box and a drop-down list or list box. It allows the user to either type a value directly into the control or choose from the list of existing options. It is very useful when a user has to select a certain option among various options.

- 1**. Edge Detection**
- AgendaO What is an edge.O What is edge detection O Usage of edge detection. O Type of edges. O Background.O Edge detection methods O Gradient based methods. O Zero Crossing based. O Proposed Algorithm.
- EdgesO Abrupt change in the intensity of pixels.O Discontinuity in image brightness or contrast.O Usually edges occur on the boundary of two regions .
- Edge DetectionO Process of identifying edges in an image to be used as a fundamental asset in image analysis.O Locating areas with strong intensity contrasts.
- Edge Detection UsageO Reduce unnecessary information in the image while preserving the structure of the image.O Extract important features of an image O Corners O Lines O CurvesO Recognize objects, boundaries, segmentation.O Part of computer vision and recognition.
- Edge TypesO Step EdgeO Ramp EdgeO RidgeO Roof
- Edge Detection Background O Classical Gradient Edge detection. O Sobel, Prewitt, Kirsch and Robinson. O Gaussian based filters O Marr and Hildreth. O Canny O Shunck, Witkin and Bergholm. O Wavelets used for different scales. O Heric and Zazula and Shih and Tseng. O Fuzzy Logic and Neural Networks.

- Edge Detection StepsO Smoothing: Noise Reduction.O Enhancement: Edge sharpening.O Detection: Which to discard and which to maintain. O Thresholding.O Localization: determine the exact location of an edge. O Edge thinning and linking are usually required in this step.
- Methods of Edge DetectionO Gradient methods (First Order Derivative) O local maxima and minima using first derivative in an image. O Compute Gradient magnitude horizontally and vertically.O Zero-crossing methods (Second Order Derivative) O locate zeros in the second derivative of an image. O Laplacian of an Image.
- Gradient based Edge DetectionO Best used for abrupt discontinuities.O Perform better in less noised imagesO Magnitude of the gradient - strength of the edge .O Direction - opposite of the edge direction. Gy G Gx 2 Gy 2 Gx Gy tan 1 Gx
- Cont. Gradient based Edge DetectionO Roberts Edge Detector.O Prewitt Edge Detector.O Sobel Edge Detector,O Canny Edge Detector.
- Cont. Gradient based Edge Detection - RobertsO 2X2 Convolution MaskO Convolution Mask O Gx Gy 1 0 0 -1 0 -1 1 0O Differences are computed at the interpolated points [i+1/2, j+1/2] and not [i, j].O Responds to edge with 450.
- Cont. Gradient based Edge Detection - PrewittO 3X3 Convolution MaskO Convolution Mask O Gx -1 0 1 Gy 1 1 1 -1 0 1 0 0 0 -1 0 1 -1 -1 -1O The differences are calculated at the center pixel of the mask.

- **1. Digital Image Processing** • Digital Image Processing denotes the process of digital images with the use of digital computer. • Digital images are contains various types of noises which are reduces the quality of images. Noises can be removed by various enhancement techniques. • Noise is anything in the image that are unwanted or undesired information Examples: – Light fluctuations – Sensor noise – Transmission 1
- Smoothing • Smoothing is often used to reduce noise within an image. • Image smoothing is a key technology of image enhancement, which can remove noise in images. So, it is a necessary functional module in various image-processing software. • Image smoothing is a method of improving the quality of images. • Smoothing is performed by spatial and frequency filters 2
- Spatial filtering • Spatial filtering term is the filtering operations that are performed directly on the pixels of an image. The process consists simply of moving the filter mask from point to point in an image. – Smoothing spatial filters – Sharpening spatial filters 3
- Smoothing Spatial Filters • Smoothing filters are used for noise reduction and blurring operations. • It takes into account the pixels surrounding it in order to make a determination of a more accurate version of this pixel. • By taking neighboring pixels into consideration, extreme “noisy” pixels can be filtered out. • Unfortunately, extreme pixels can also represent original fine details, which can also be lost due to the smoothing process 4
- Cont… Smoothing spatial filters Linear Nonlinear Mean Weiner Gaussian Min Max Median 5

- Smoothing Linear Filters • Smoothing linear spatial filter is the average of the pixels contained in the neighborhood of the filter mask. • Averaging filters or low pass filters. – Mean filter – Gaussian filter 6
- Mean Filter/Box Filter • Mean filtering is simply to replace each pixel value in an image with the mean (`average') value of its neighbors, including itself. • 3×3 normalized box filter: 20 40 10 10 20 20 10 20 30 20 40 10 10 20 20 10 20 30 7
- Cont… • Image smoothed with 3□3, 5□5, 9□9 and 11 □11 box filters 8
- Cont… • Often a 3×3 square matrix is used, although larger matrix (e.g. 5×5 squares) can be used for more severe smoothing. • Drawback: – smoothing reduces fine image detail 9
- Gaussian Filter • A Gaussian filters smoothens an image by calculating weighted averages in a filter box. • It is used to `blur' images and remove detail and noise. • Gives more weight at the central pixels and less weights to the neighbors. • The farther away the neighbors, the smaller the weight. • Gaussian Blurs produce a very pure smoothing effect without side effects. 10
- Gaussian Smoothing Example Original Sigma = 3 11
- Smoothing Non Linear Filters • Nonlinear spatial filters are Order-statistics filters whose response is based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result. – Min and Max Filter – Median Filter – Midpoint Filter 12

- Min and Max Filter • The minimum filter selects the smallest value within the pixel values and maximum filter selects the largest value within of pixel values. • Max filter is useful for finding the brightest points in an image i.e. it removes salt noise. • Min filter is useful for finding the darkest points in an image i.e. it removes pepper noise. • Both filters require a data sort. 13
- Median Filter • It smooth a few pixels whose values differ significantly from their surroundings without affecting the other pixels. • Best suited for “salt and pepper” noise • Salt-and pepper noise can occur due to a random bit error in a communication channel 14
- Comparison Of Median And Box Filter Noisy image 5x5 median filtered 5x5 box filter 15
- Midpoint Filter • The Midpoint filter blurs the image by replacing each pixel with the average of the highest pixel and the lowest pixel (with respect to intensity) within the specified window size. • Midpoint = (darkest + lightest)/2 16
- Frequency filtering • The basic model for filtering in the frequency domain where F(u,v): the Fourier transform of the image to be smoothed H(u,v): a filter transfer function • Smoothing is fundamentally a low pass operation in the frequency domain. • It is computationally faster than spatial domain. 17
- Operation of frequency filter 18
- Major filter categories • Typically, filters are classified by examining their properties in the frequency domain: (1) Low-pass for smoothing (2) High-pass for sharpening (3) Band-pass (4) Band-stop 19
- Example 20 Original signal Low-pass filtered High-pass filtered Band-pass filtered Band-stop filtered

THANK YOU

This content is taken from the text books and reference books prescribed in the syllabus.