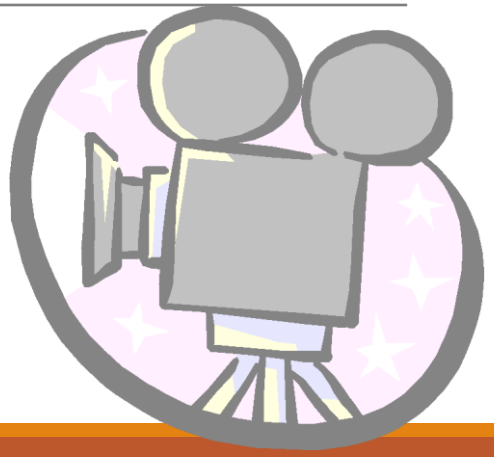
Image Processing: An Overview
CS-317/CS-341



Syllabus

CS341	Image Processing	L	T	P
		2	1	1

Digital Image Fundamental: Elements of Visual Perception- Structure of the human eye, Image formation in the eye, brightness adaptation and discrimination; light and electromagnetic spectrum, image sensing and acquisition, image sampling and quantization, basic relationships between pixels, linear and nonlinear operations.

Image Enhancement:Point processing: Contrast stretching, power-law and gamma transformation. Histogram processing: histogram equalization and matching.

Filtering and Restoration:Degradation function and Noise Models, Spatial Domain Filtering: Correlation and Convolution, Smoothing Linear and Nonlinear Filters: Mean and Median Filters, Adaptive Filtering, Sharpening Linear and Nonlinear Filters: Derivative, Laplacian, Unsharp Masking, High-boost Filtering. Frequency Domain Filtering: Filtering: Low-pass (Smoothing) & High-Pass (Sharpening) Ideal, Butterworth and Gaussian Filtering, Unsharp Masking and High-Boost Filtering, Homomorphic Filtering, Periodic Noise Reduction and Inverse Filtering & Wiener Filtering.

Image Reconstruction from Projections: Transmission tomography, reflection tomography, emission tomography, magnetic resonance imaging, and projection based image processing. Radon transform, back projection operator, projection theorem, inverse radon transform, convolution filter back projection, reconstruction from blurred noisy projections, Fourier reconstruction, fan-beam reconstruction, algebraic methods and three dimensional tomography.

Image Compression: Introduction, Error criterion- objective and subjective criterion; Lossy compression- transform domain compression, JPEG compression, block truncation compression, vector quantization compression; Lossless compression- Huffman coding, arithmetic coding, transformed coding, run-length coding, block coding, quad tree coding, and contour coding.

Suggested Readings:

1. A. K. Jain, Fundamentals of Digital Image Processing, Pearson Education India, 2015.
2. Rafael Gonzalez, Richard Woods, Digital Image Processing, Pearson Education India, 2017.
3. R. H. Vollmerhausen, R.G. Driggers, Analysis of Sampled Imaging Systems, SPIE Press, 2001.
4. B. Chanda, D. D. Majumder, Digital Image Processing and Analysis, PHI, 2011.
5. A. C. Bovik, Handbook of Image and Video Processing (Communications, Networking & Multimedia). Academic Press, 2005.
6. J. S. Lim, Two Dimensional Signal and Image Processing, Prentice-Hall, Englewood Cliffs, New Jersey, 1989.
7. D. E. Dudgeon, Russell M. Mersereau, Multidimensional Signal Processing, Prentice Hall, 1983.
8. S. G. Wilson, Digital Modulation and Coding, Pearson Education, 2003.
9. H. Maître, From Photon to Pixel: The Digital Camera Handbook, Wiley- 2017.

Topics of Course

- Digital Image Fundamental
- Image Enhancement
- Filtering and Restoration
- Image Reconstruction from Projections
- Image Compression

Three related sub-fields

- Image Processing
- Computer Graphics
- Computer Vision

Digital Image?

What is this?

1000000110011101001011100100110101001000001
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ASCII Table

Dec	Hex	Char	Action (*if non-printing*)	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	0	NUL	(null)	32	20	Space	64	40	@	96	60	`
1	1	SOH	(start of heading)	33	21	!	65	41	A	97	61	a
2	2	STX	(start of text)	34	22	"	66	42	B	98	62	b
3	3	ETX	(end of text)	35	23	#	67	43	C	99	63	c
4	4	EOT	(end of transmission)	36	24	$	68	44	D	100	64	d
5	5	ENQ	(enquiry)	37	25	%	69	45	E	101	65	e
6	6	ACK	(acknowledge)	38	26	&	70	46	F	102	66	f
7	7	BEL	(bell)	39	27	'	71	47	G	103	67	g
8	8	BS	(backspace)	40	28	(	72	48	H	104	68	h
9	9	TAB	(horizontal tab)	41	29	)	73	49	I	105	69	i
10	A	LF	(NL line feed, new line)	42	2A	*	74	4A	J	106	6A	j
11	B	VT	(vertical tab)	43	2B	+	75	4B	K	107	6B	k
12	C	FF	(NP form feed, new page)	44	2C	,	76	4C	L	108	6C	l
13	D	CR	(carriage return)	45	2D	-	77	4D	M	109	6D	m
14	E	SO	(shift out)	46	2E	.	78	4E	N	110	6E	n
15	F	SI	(shift in)	47	2F	/	79	4F	O	111	6F	o
16	10	DLE	(data link escape)	48	30	0	80	50	P	112	70	p
17	11	DC1	(device control 1)	49	31	1	81	51	Q	113	71	q
18	12	DC2	(device control 2)	50	32	2	82	52	R	114	72	r
19	13	DC3	(device control 3)	51	33	3	83	53	S	115	73	s
20	14	DC4	(device control 4)	52	34	4	84	54	T	116	74	t
21	15	NAK	(negative acknowledge)	53	35	5	85	55	U	117	75	u
22	16	SYN	(synchronous idle)	54	36	6	86	56	V	118	76	v
23	17	ETB	(end of trans. block)	55	37	7	87	57	W	119	77	w
24	18	CAN	(cancel)	56	38	8	88	58	X	120	78	x
25	19	EM	(end of medium)	57	39	9	89	59	Y	121	79	y
26	1A	SUB	(substitute)	58	3A	:	90	5A	Z	122	7A	z
27	1B	ESC	(escape)	59	3B	;	91	5B	[	123	7B	{
28	1C	FS	(file separator)	60	3C	<	92	5C	\	124	7C	|
29	1D	GS	(group separator)	61	3D	=	93	5D	]	125	7D	}
30	1E	RS	(record separator)	62	3E	>	94	5E	^	126	7E	~
31	1F	US	(unit separator)	63	3F	?	95	5F	_	127	7F	DEL

American standard code for information exchange

128 characters are represented by different decimal numbers

As $2^7=128$

So 7 bits are required for representing ASCII code

Decimal to Binary & Binary to Decimal Conversion

2	65	1	LSB
2	32	0	
2	16	0	
2	8	0	
2	4	0	
2	2	0	
	1	1	MSB

$(65)_{10} = (1000001)_2$

Binary to decimal

1000001

$1\times2^6+0\times2^5+0\times2^4+0\times2^3+0\times2^2+0\times2^1+1\times2^0$

64+0+0+0+0+0+1

65

ANKITA

ASCII: A: 65 N: 78 K: 75 I:73 T:84 A:65

A	N	K	I	T	A
65	78	75	73	84	65

1000001 1001110 1001011 1001001 1010100 1000001

100000110011101001011100100110101001000001

What is this?

100000110011101001011100100110101001000001
100000110011101001011100100110101001000001
100000110011101001011100100110101001000001
100000110011101001011100100110101001000001
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100000110011101001011100100110101001000001

1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001
1000001	1001110	1001011	1001001	1010100	1000001

(a)

65	78	75	73	84	65
65	78	75	73	84	65
65	78	75	73	84	65
65	78	75	73	84	65
65	78	75	73	84	65
65	78	75	73	84	65
65	78	75	73	84	65

(b)

A	N	K	I	T	A
A	N	K	I	T	A
A	N	K	I	T	A
A	N	K	I	T	A
A	N	K	I	T	A
A	N	K	I	T	A
A	N	K	I	T	A

(c)

A PICTURE IS WORTH A THOUSAND WORDS

A picture is worth a thousand words is a phrase which talks about how a visual image can mean a lot more than words.

Is Worth

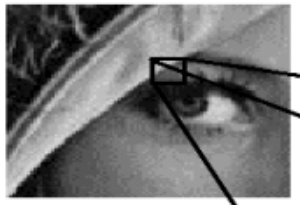
What is Digital Image?

- An image is a 2D matrix where each and every cell corresponds to a pixel value.

Or

- Digital Image is a two-dimensional function $f(x, y)$, x and y are spatial coordinates. The amplitude of f is called intensity or gray level at the point (x, y)

Matrix representation of an image



196	198	198	188	148	108
199	200	182	130	100	98
203	178	116	85	100	95
173	99	83	85	95	98
94	78	80	79	94	87
71	78	86	76	80	72

What is Digital Image Processing (DIP)?

Digital Image Processing

process digital images by means of computer, it covers low, mid, and high-level processes

Pixel

the elements of a digital image

What is DIP? (cont…)

The continuum from image processing to computer vision can be broken up into low, mid and high-level processes

Low Level Process	Mid Level Process	High Level Process
Input: Image **Output:** Image **Examples:** Noise removal, image sharpening	**Input:** Image **Output:** Attributes **Examples:** Object recognition, segmentation	**Input:** Attributes **Output:** Understanding **Examples:** Scene understanding, autonomous navigation

Topics of Course

- Image acquisition – (low-level) digital representation of the world scenes

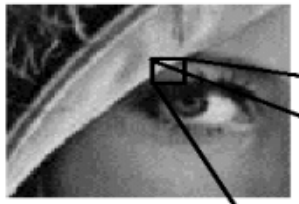
- Image processing – noise removal, smoothing, sharpening, contrast enhancement, alter the appearance of an image

- Image compression – efficiently represent image data for storage (save disk space) and communication (save network bandwidth)

What numbers?

How many numbers?

How large/small should the numbers be?



196	198	198	188	148	108
199	200	182	130	100	98
203	178	116	85	100	95
173	99	83	85	95	98
94	78	80	79	94	87
71	78	86	76	80	72

Image Processing

Image processing – noise removal, smoothing, sharpening, contrast enhancement, alter the appearance of an image

Noise removal

Image Processing

Image processing – noise removal, smoothing, sharpening, contrast enhancement, alter the appearance of an image

Sharpening

Image Processing

Image processing – noise removal, smoothing, sharpening, contrast enhancement, alter the appearance of an image

Blurring/smoothing

Image Processing

Image processing – noise removal, smoothing, sharpening, contrast enhancement, alter the appearance of an image

Contrast enhancement

Applications
&
Research Topics

Digital Image Watermarking

+ 011111 =

Digital Image Compression

245,760 bytes

69,632 bytes

5,951 bytes

Image Fusion

Suggested Readings

- **Digital Image Processing by Rafel Gonzalez, Richard Woods, Pearson Education India, 2017.**

- **Fundamental of Digital image processing by A. K Jain, Pearson Education India, 2015.**

Thank you