M30242 Graphics and Computer Vision

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Lecture 1 Introduction to Computer Vision

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Aims & Objectives

- Analyse compute vision problems and formulate solutions from integration of essential computer vision methods.
- Implement and evaluate computer vision methods using appropriate image processing and computer vision tools (Matlab toolboxes).

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Computer Vision

- The aim of computer vision is to make computers see and understand.
- The approach is to use computers to analyse images to derive information about imaged 3D scenes: identify object, understand scenes, etc.

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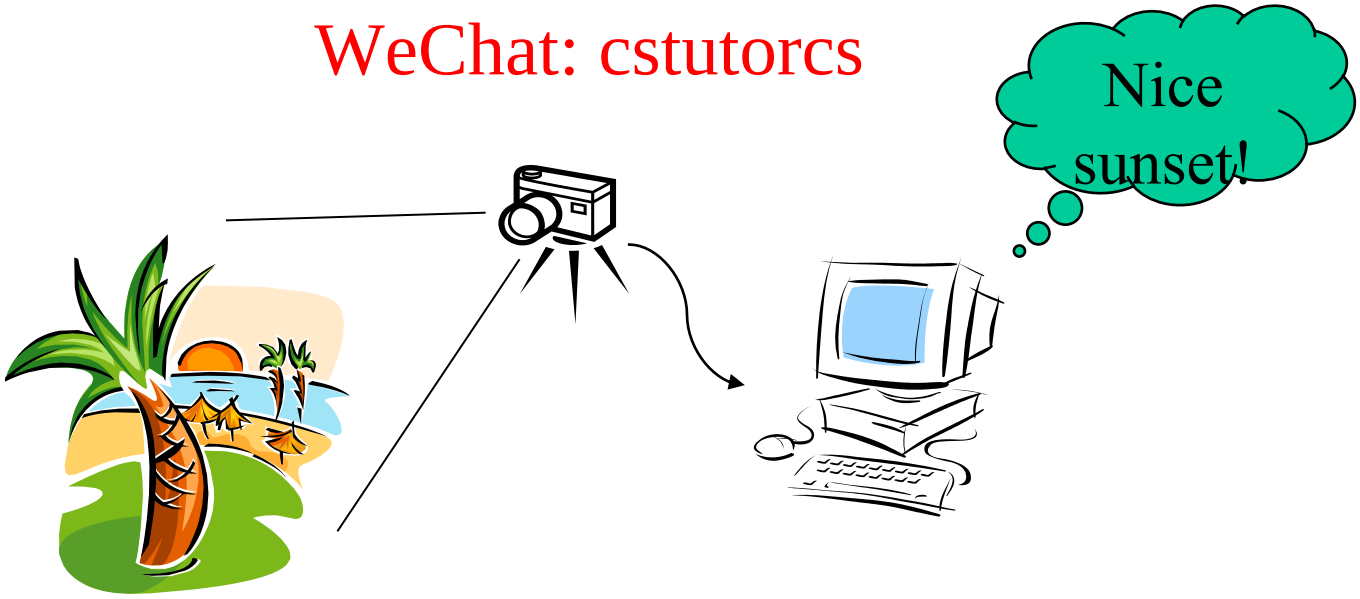

Computer Vision Under Different Names

- Somewhat interchangeable names, with somewhat different implications.
- Computer Vision
  - Most general term.
- Image Understanding
  - Automated scene analysis (e.g., satellite images, robot navigation).
- Machine Vision
  - Industrial, factory-floor systems for inspection, measurements, part placement, etc.

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Computer Vision Is Hard

- Computers take numbers and interpret their values (e.g., display a value with a colour on screen), but not much more than that.
- What do these numbers mean?

A few rows of columns 1 through 13 (red channel) of a picture (next slide)

43	48	53	53	45	33	21	14	88	95	94	74	44
26	35	38	26	11	14	37	61	65	56	40	20	8
42	27	12	13	26	37	37	32	3	8	20	19	10
32	27	24	27	30	25	11	3	15	3	3	9	27
4	20	33	28	9	3	3	6	3	3	5	4	3
11	2	2	1	1	0	1	2	3	1	4	21	46
0	3	0	0	7	6	9	4	99	11	7	23	0
0	5	3	0	0	0	22	73	126	21	23	69	27
68	82	85	98	113	90	77	107	96	1	7	95	66
30	82	126	166	193	152	104	106	104	14	36	120	106
94	161	195	188	178	136	110	127	111	55	56	89	79
212	212	165	122	85	81	76	85	74	27	18	25	31
192	156	78	35	69	108	103	86	7	9	7	18	44
37	42	20	6	25	42	26	6	9	11	8	23	47
20	16	17	20	17	8	4	7	7	24	44	54	52
15	7	1	1	1	1	13	28	41	33	23	19	21
0	0	0	0	0	5	21	36	16	17	33	70	114
0	6	16	25	28	26	16	30	25	23	36	78	126
81	79	78	78	77	74	71	69	82	54	30	35	60
115	98	74	55	48	51	58	63	59	47	40	50	69
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89	112	107	62	29	30	40	39	50	40	41	48	39
170	116	54	29	30	31	18	5	48	46	38	25	31
168	87	22	23	42	31	8	0	48	51	34	11	34
63	43	36	47	46	32	24	29	46	40	29	31	67
1	30	48	40	31	40	49	49	41	26	36	75	112
39	47	34	11	19	50	57	39	40	32	57	107	133
67	45	24	22	39	55	47	29	43	61	87	111	118
44	25	30	62	75	53	34	35	47	89	112	102	96
28	32	39	45	47	47	44	42	94	121	110	108	141
23	38	51	48	38	37	54	71	95	113	124	134	133
25	45	58	47	30	36	70	105	97	104	140	155	122
42	46	47	41	40	57	91	121	105	108	146	151	110
60	43	28	35	64	93	111	119	118	121	141	128	107
63	39	24	43	87	121	126	117	131	134	130	113	113
45	37	39	63	99	126	131	127	139	137	122	120	124
26	38	58	81	103	119	132	137	145	135	118	134	133

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Cont'd

- How many details can you pick out from this? – an recognition problem.
- For a computer to do the same, it must be able to
  - recognise the way in which these numbers are organised. E.g., a pixel's relationship with its neighbours;
  - interpret the patterns and bestow them with visual meanings, e.g. a black rectangle.

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Computer Vision Problem

- It usually involve the inverse mapping of perspective projection (from images to 3D entities).
- It is a **under-constrained** and **ill-defined** problem.
  - From 3D objects to 2D images is a many-to-one mapping.
  - A variety of surfaces with different *material* and *geometrical* properties, possibly under different *lighting* conditions and view angles, could lead to ***identical*** images. Therefore it is hard, if not impossible, to decide the 3D scene that 2D images represent.
- In general, it does not have a unique solution.

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Vision Is Not One-to-One

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More Examples

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Not So Hard for Human

- Human vision system deals a broad range of visual cues with little effort
  - Different cues, e.g., shading, textures, edges, etc

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- Therefore, it is expected that understanding how our brains work, e.g., the different mechanisms for working with the different cues, would help to solve computer vision problems.

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- Unfortunately, in most cases, we don't understand how our brains perform recognition tasks.

Visual Cues: Textures

What is it?

If you can recognise the image, how have you done it?

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Visual Cues: Shapes

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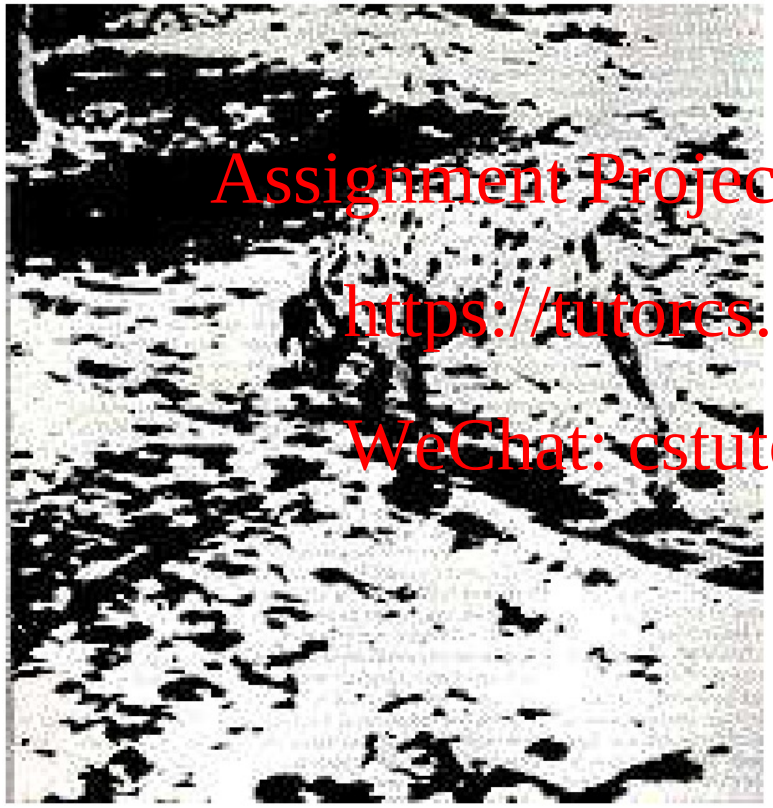
Lots of information is lost in this image. However, it doesn't prevent you from recognising the scene

Grouping of Visual Cues



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What is in this image? What tells you what it is?

Where do the non-existent lines come from?

Is Your Vision System Reliable?

- In most cases our vision system is reliable, but illusion exists.

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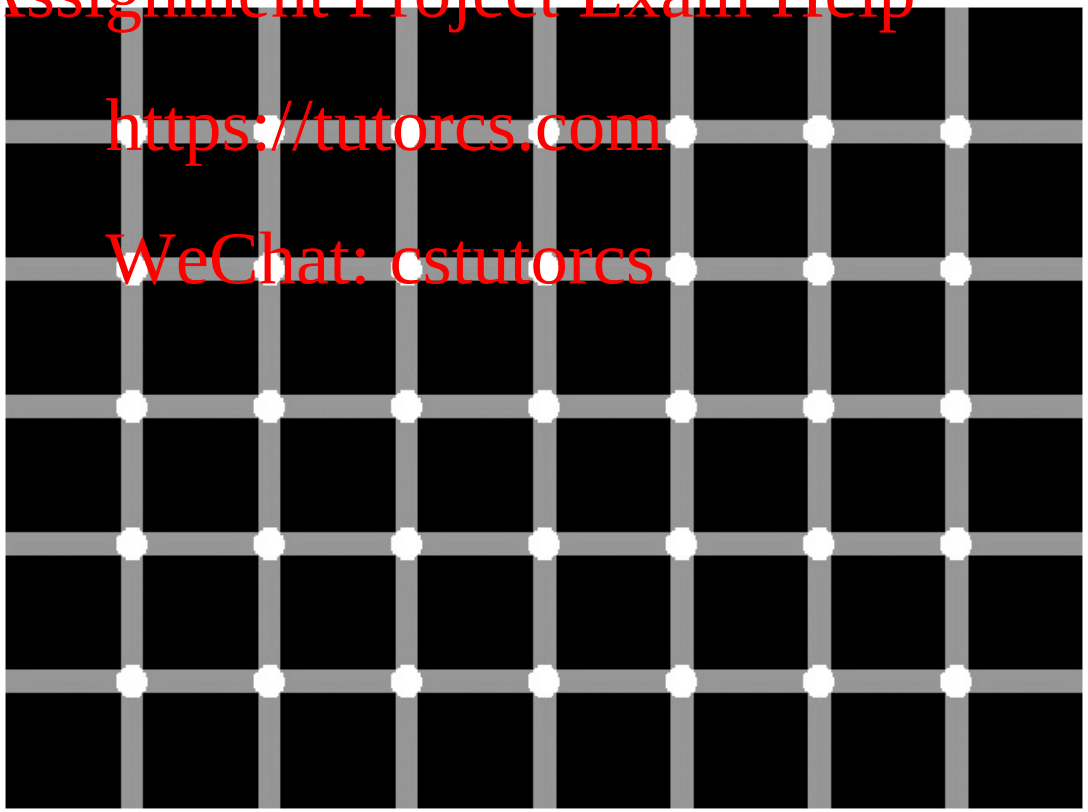

Illusions

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Two identical patterns of stripes – the intensities of stripes are the same

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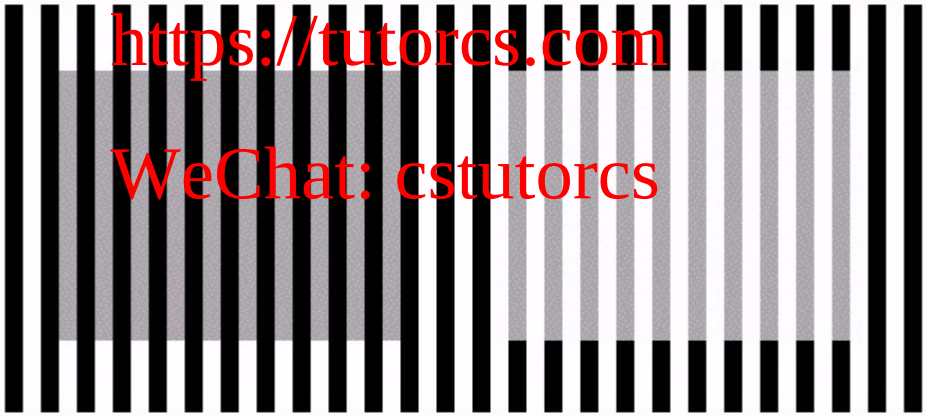

Are the intensities of the stripes still the same?

Study of Human Vision

- The intriguing facts about human vision have puzzled vision scientists for many decades
  - What scientific principles are behind them?
  - What mechanisms are working in human brain?

  (For a good treatment of the topics, see Palmer, S.E., Vision Science: Photons to Phenomenology, MIT Press.)
- Computer vision scientists wish to find theories and/or methods to achieve such capabilities.

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Related Fields

- Computer vision theories, technology and applications spread a wide range of subjects and areas.
- The theories and methods have been accumulated from the research work in
  - image processing,
  - statistical pattern recognition,
  - artificial intelligence and etc.
- Applications can be found in
  - Robotics,
  - biological vision,
  - medical imaging,
  - computer graphics,
  - human-computer interaction, etc.

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Applications: Visual Inspection

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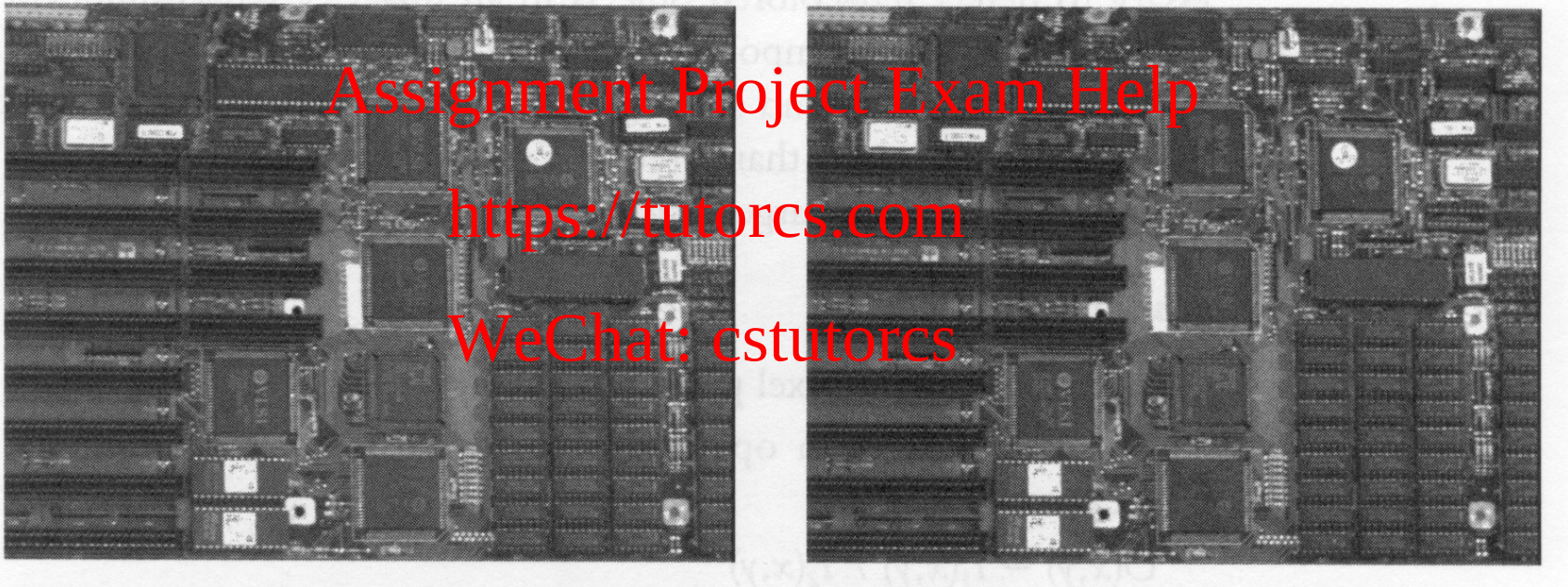

Any difference between the two images?

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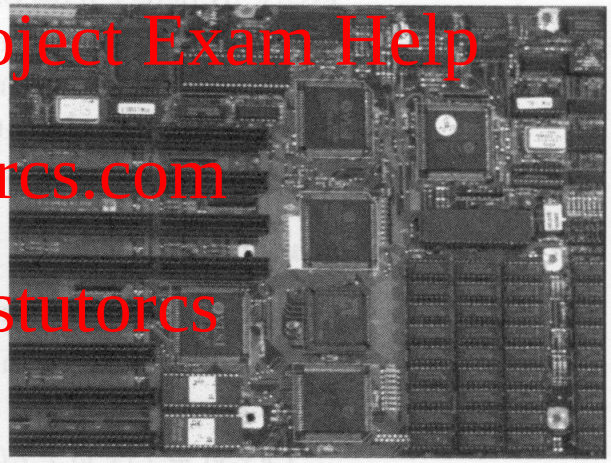
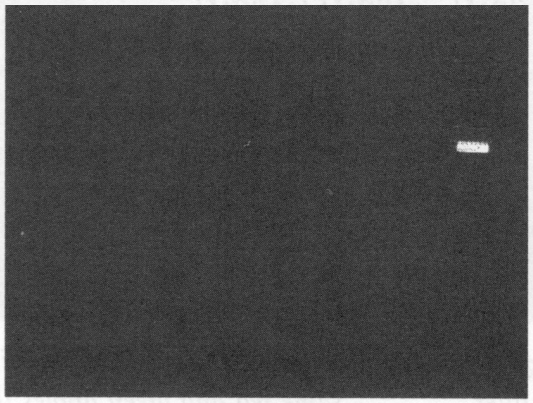
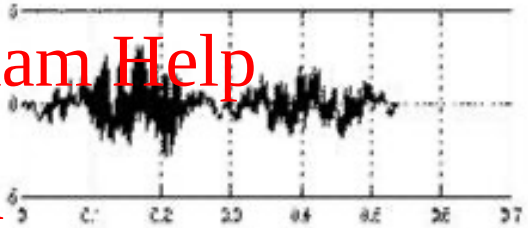




Biometrics



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Target Recognition

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Interpretation of Aerial Photography

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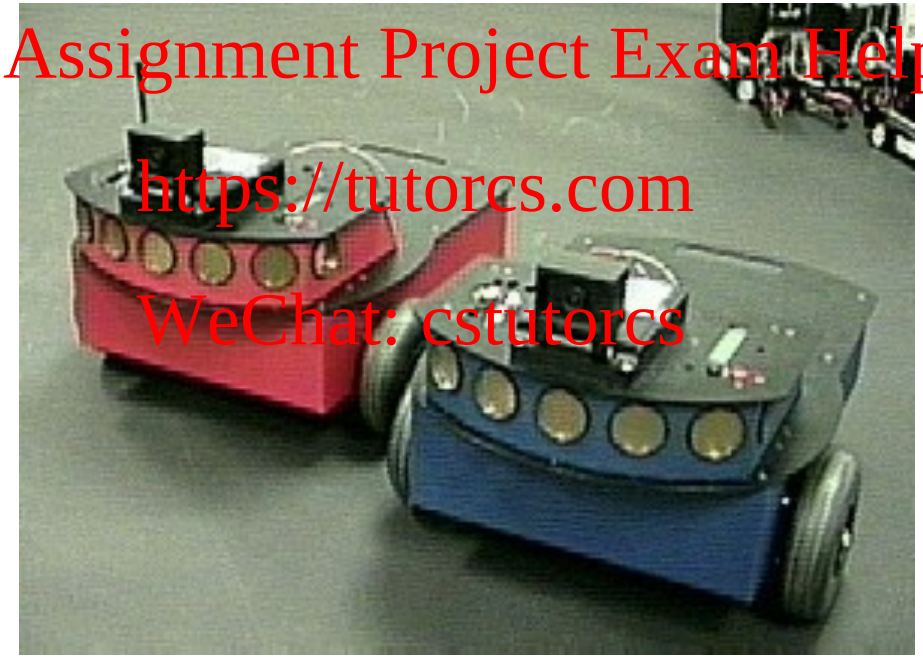
Autonomous Vehicles

- Land, Underwater, Space



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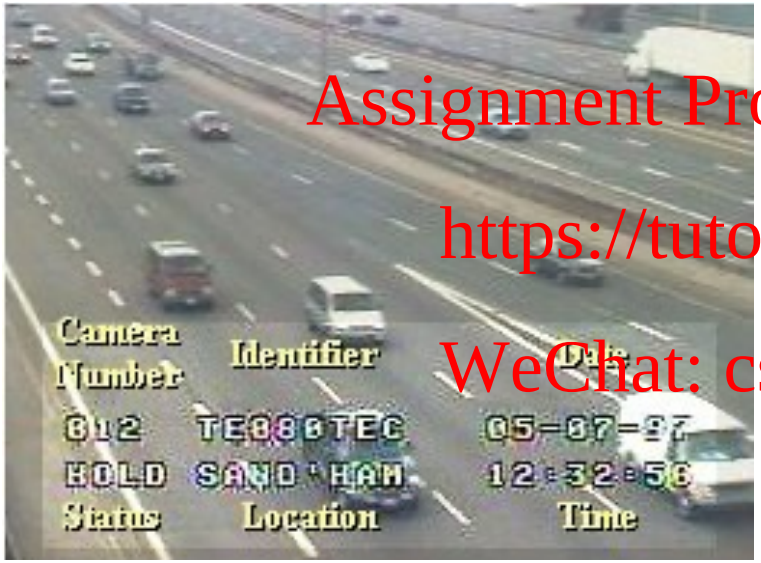
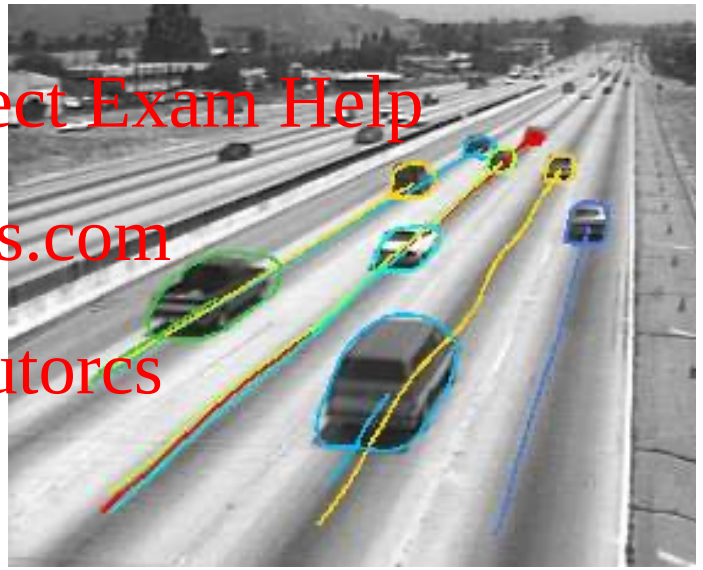
Traffic Monitoring





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Augmented Reality
– inserting artificial objects into a scene

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Face Detection

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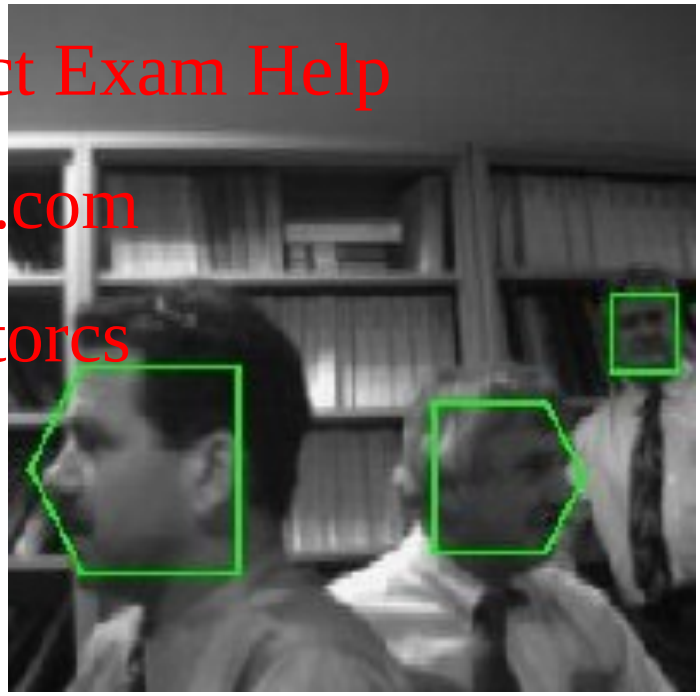

Face Recognition

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Human Activity Recognition

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Sources for Further Readings

- Journals
  - IEEE Transactions on Pattern Analysis and Machine Intelligence (PAMI)
  - International Journal of Computer Vision (IJCV)
  - Computer Vision and Image Understanding (CVIU)
- Conference proceedings
  - Computer Vision and Pattern Recognition (CVPR)
  - International Conference on Computer Vision (ICCV)
  - International Conference on Pattern Recognition (ICPR)

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