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From Image Processing To Computer Vision

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Outline

- Introduction to Digital Images.
- What is Digital Image Processing?
- Why study Digital Image Processing?
- Digital Image Processing Steps.
- Computer Vision.

Digital Image

- Why do we need Digital Images?
  - It help us to see invisible objects due to:
    - Opaqueness (e.g., see through human body).
    - Far distance (e.g., remote sensing).
    - Small size (e.g., light microscopy).
    - Other signals (e.g., seismic) can also be translated into images to facilitate the analysis.
  - A picture is worth a thousand words!

Digital Image

- What is a Digital Image?
  - A digital image is an array of numbers.

45	51	88	89	94	100	98	103	104	104
47	146	102	100	118	103	125	101	99	100
34	135	33	32	53	88	73	34	29	30
48	84	39	63	55	25	33	32	31	31
151	43	114	151	152	135	134	129	134	145
208	115	35	33	36	39	39	72	93	176
210	171	39	34	39	40	109	86	77	208
209	175	40	39	37	53	90	39	80	222
200	185	49	38	35	75	72	45	90	197
66	85	39	35	33	52	86	49	49	83

Digital Image

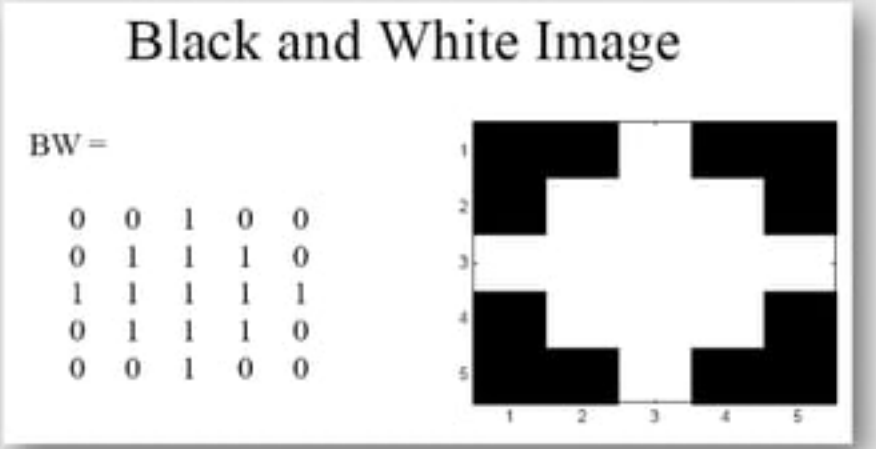
- An image is a two-dimensional function:
  - f(x,y).
  - x and y are the spatial coordinates.
  - f(x,y) is the intensity of the image at the point (x,y).
- In a digital image, x, y, and f(x,y) are finite, discrete quantities.
- These elements are called picture elements.

Digital Image

- Digital Image Types:
  1. Black and White image.
  2. Gray scale image.
  3. Colored image.

Digital Image Types

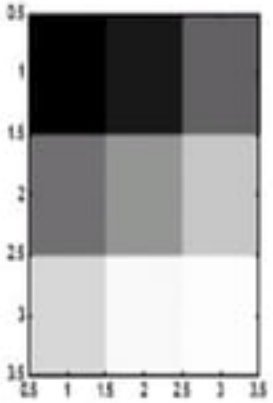
- Binary Image (0-1)



Digital Image Types

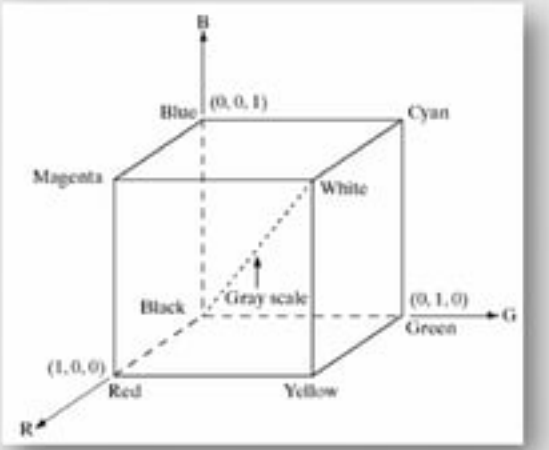
- Gray Scale Image (0-255)

$$X = \begin{matrix} 0 & 25 & 100 \\ 115 & 150 & 200 \\ 215 & 250 & 255 \end{matrix}$$



Digital Image Types

- Color RGB Representation



What is DIP?

- DIP is the use of computer algorithms to perform image processing on digital images.
- Three types of processes from image processing to computer vision:
  - Low-level processes:
    - Input and output are images.
    - such as noise reduction, contrast enhancement, image sharpening.
  - Mid-level processes:
    - input are images.
    - outputs are attributes extracted from those images.
    - such as segmentation.
  - High-level processes:
    - understanding, recognition.

Why DIP?

- Image & video become a major communication media.
- Image data need to be accessed at a different time or location:
  - Limited storage space and transmission bandwidth.
- Image data might experience no ideal acquisition, transmission or display
  - Fight against various noise (errors).
- Image data need to be analyzed automatically
  - Reduce the burden of human operators by teaching a computer to see.

Why DIP?

- Image data might contain sensitive content
  - Fight against piracy, counterfeit and forgery.
- Enhance and restore images
  - Remove scratches from an old movie.
  - Improve visibility of tumor in a radiograph.
- Extract information from images
  - Read the ZIP code on a letter.
- To produce images with artistic effect.

From IP To CV

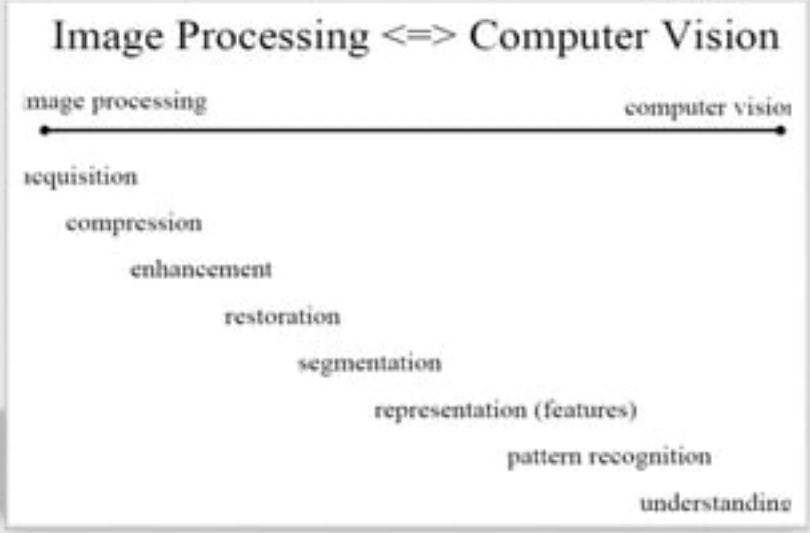


Image Processing <=> Computer Vision
mage processing
computer vision
equisition
compression
enhancement
restoration
segmentation
representation (features)
pattern recognition
understanding

From IP To CV

1. Image Acquisition.
2. Image Enhancement.
3. Image Restoration.
4. Color Image Processing.
5. Image Compression.
6. Image Segmentation.
7. Representation & Description.
8. Object Recognition.

Image Acquisition

- To create a digital image, we need to convert the continuous sensed data into digital form

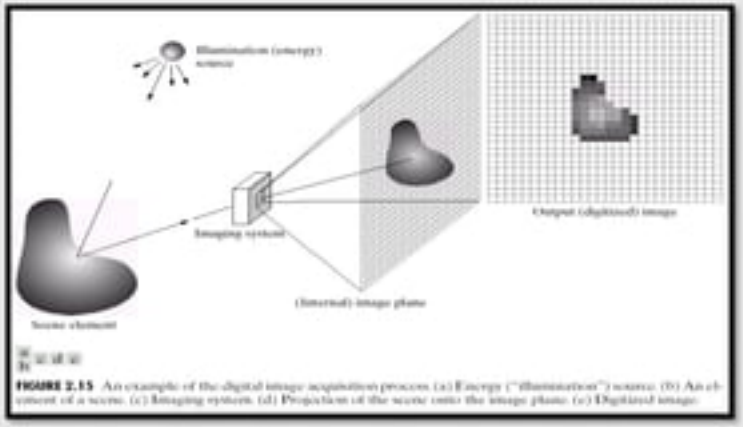


Image Enhancement

- The principal objective of enhancement is to process an image so that the result is more suitable than the original image.

- Image Enhancement techniques are very much problem oriented:
  - A method that is quite useful for enhancing X-ray images may not necessarily be the best approach for enhancing pictures of Mars transmitted by a space probe.

Image Enhancement

- Image Enhancement approaches fall into two broad categories :
  - Spatial domain methods.
  - Frequency domain methods.
- Spatial domain processing techniques are based on direct manipulation of pixels in an image.
- Frequency domain processing techniques are based on modifying the Fourier transform of an image.

Image Enhancement

√Image Restoration

- Image restoration is an area that also deals with improving the appearance of an image
  - Enhancement which is subjective.
  - Image Restoration is objective, its techniques tend to be based on mathematical or probabilistic models of image degradation.
  - Enhancement, on the other hand, is based on human subjective preferences regarding what constitutes a "good" enhancement result.

Image Restoration

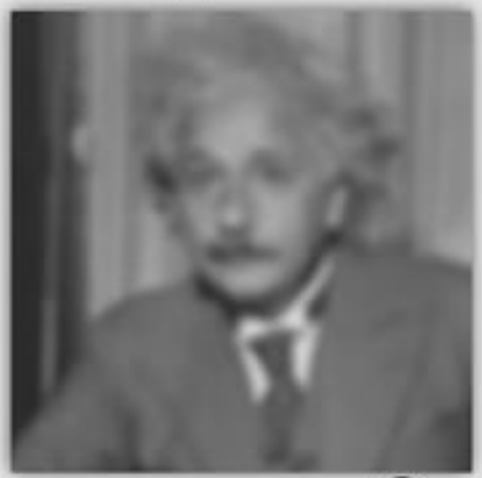
- Restoration attempts to reconstruct or recover an image that has been degraded.
  - Thus restoration techniques are oriented toward modeling the degradation and applying the inverse process in order to recover the original image.

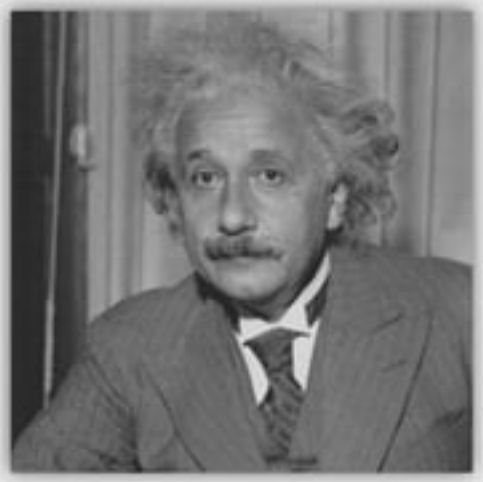
Image Restoration

- Image De-noising

Image Restoration

- Image De-blurring





Color Image Processing

- The use of color in image processing is motivated by two principal factors.
  - First, color is a powerful descriptor that often simplifies object identification and extraction from a scene.
  - Second, humans can discern thousands of color shades and intensities, compared to about only two dozen shades of gray. This second factor is particularly important in manual image analysis.

Color Image Processing

Flat Corrected

Color Image Processing

Light Corrected

Color Image Processing

Dark Corrected

Image Compression

- Image Compression deals with techniques for reducing the storage required to save an image, or the bandwidth required to transmit it.

- Although storage technology has improved significantly over the past decade, the same cannot be said for transmission capacity. This is true particularly in uses of the Internet.

- Image Compression is familiar to most users of computers in the form of image file extensions, such as the jpg file extension used in the JPEG image compression standard.

Image Compression

- Image Compression addresses the problem of reducing the amount of data required to represent a digital image.

- The underlying basis of the reduction process is the removal of redundant data. From a mathematical viewpoint, this amounts to transforming a 2-D pixel array into a statistically uncorrelated data set.

- The transformation is applied to storage of the image. Then the compressed image is decompressed to reconstruct the original image or an approximation of it.

Image Compression

Original: 100KB JPEG: 9KB JPEG: 5KB

Image Segmentation

- Segmentation procedures partition an image into its constituent parts or objects. That is, segmentation should stop when the objects of interest in an application have been isolated.

- Autonomous segmentation is one of the most difficult tasks in digital image processing.
  - A rugged segmentation procedure brings the process a long way toward successful solution of imaging problems that require objects to be identified individually.
  - On the other hand, weak segmentation algorithms almost always guarantee eventual failure.

Image Segmentation

1. In the first category, the approach is to partition an image based on abrupt changes in intensity, such as edges in an image.

Image Segmentation

2. The principal approach, in the second category are based on partitioning an image into regions that are similar according to a set of predefined criteria.

Representation & Description

- Representation and Description almost always follow the output of a segmentation stage, which usually is raw pixel data that represent image to regions, the resulting aggregate of segmented pixels usually is represented and described in a form suitable for further computer processing.
- Basically, representing a region involves two choices:
  - We can represent the region in terms of it external characteristics (its boundary).
  - We can represent it in terms of its internal characteristics (the pixels comprising the region).

Image Recognition

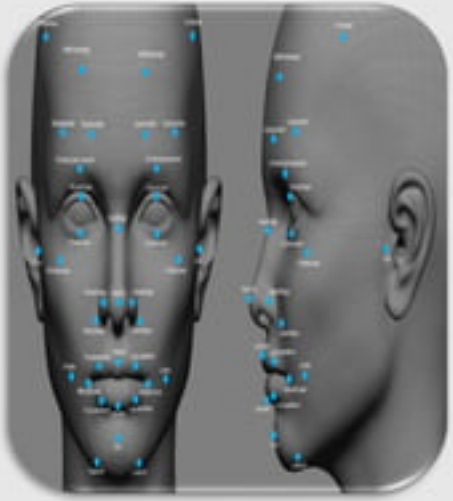
- Image recognition was already good but it's getting way, way better.
- A research collaboration is producing software that increasingly describes the entire scene portrayed in a picture, not just individual objects.
- That algorithms attempt to explain what's happening in images in language that actually makes sense.
- It spits out sentences like:
  - A group of young people playing a game of Frisbee.
  - A person riding a motorcycle on a dirt road.

Image Recognition

- It does that using two neural networks: one deals with image recognition, the other with natural language processing.
- The system uses computer learning, so it's fed a series of captioned images and it gradually learns how sentences relate to what the image shows.
- It often makes small mistakes and, occasionally, it gets things completely wrong. Clearly there's room for improvement.

Image Recognition

Image Recognition



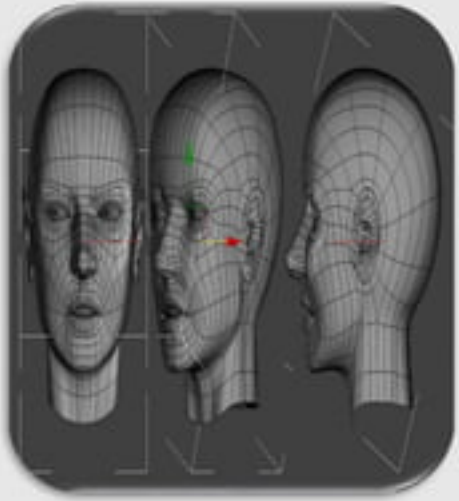


Image Recognition

Image Recognition

Image Recognition

- Face Detection and Recognition

Image Recognition

- Face Detection and Recognition

Image Recognition

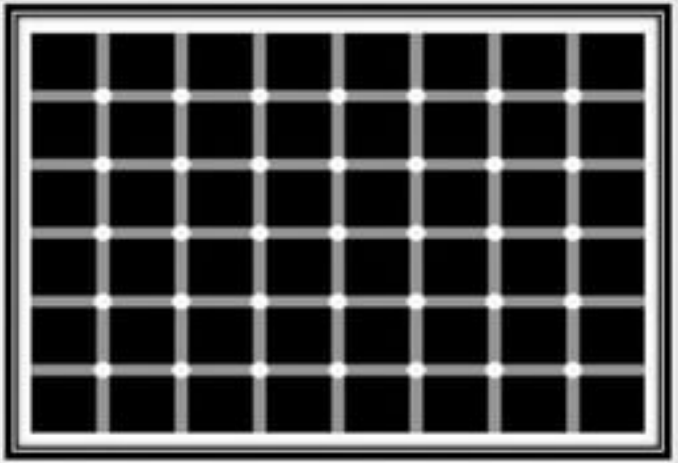
- Face Detection and Recognition

Image Recognition

- Face Detection and Recognition

HVS: Visual Illusion

- Find the black dot

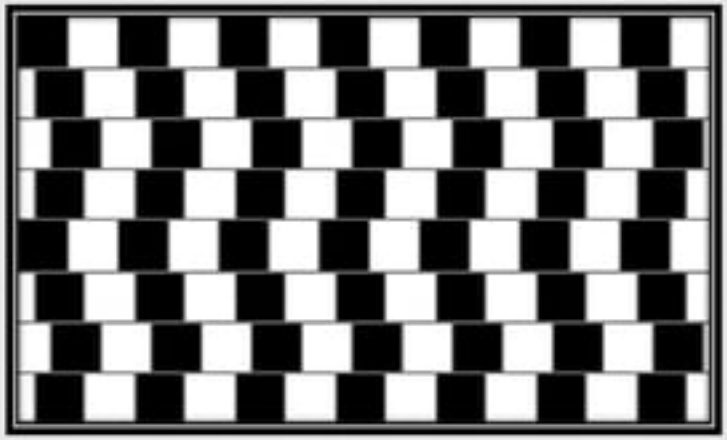


HVS: Visual Illusion

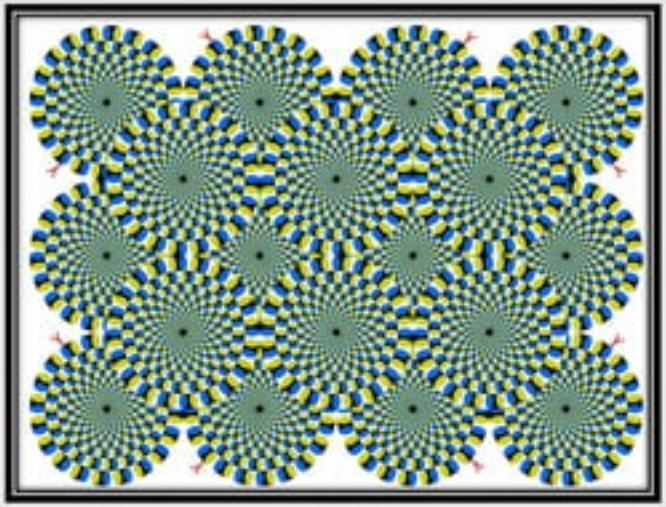
- What is this?

HVS: Visual Illusion

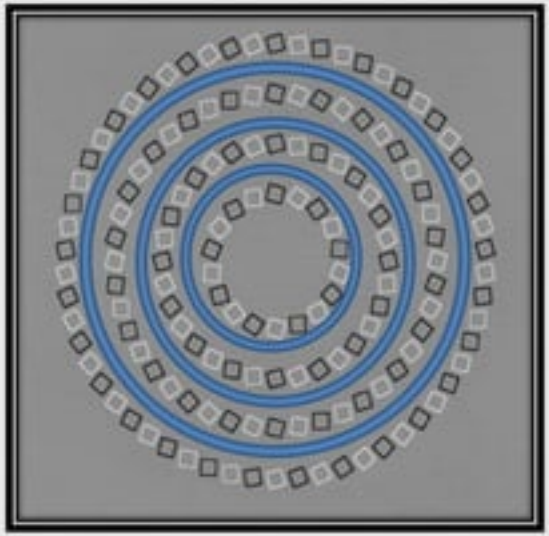
- Which lines are straight?



HVS: Visual Illusion



HVS: Visual Illusion



Computer Vision

- Make computers understand images and video.

Computer Vision

- Scene Completion:

Computer Vision

- Scene Completion:

Computer Vision

Nearest neighbor scenes from database of 2.3 million photos

Computer Vision

- Specific Recognition Tasks

Computer Vision

1. Scene Categorization or Classification:
   - Outdoor, indoor.
   - City, forest, factory.

Computer Vision

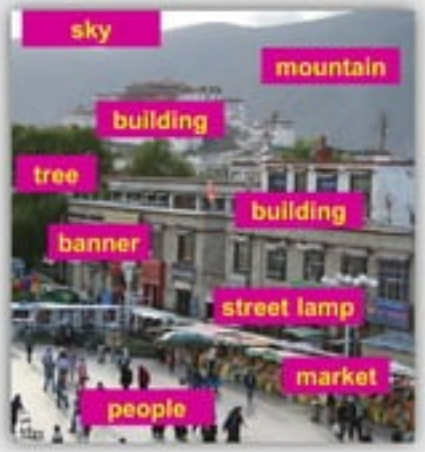
2. Image Annotation:
   - street, people, building, mountain, tourism, cloudy, brick.

Computer Vision

- Object Detection:
  - find pedestrians.

Computer Vision

3. Image Segmentation



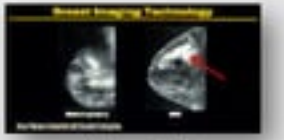
Computer Vision

- Vision is really hard
  - Vision is an amazing feat of natural intelligence

Computer Vision

- Why Computer Vision matters?

Safety



Health

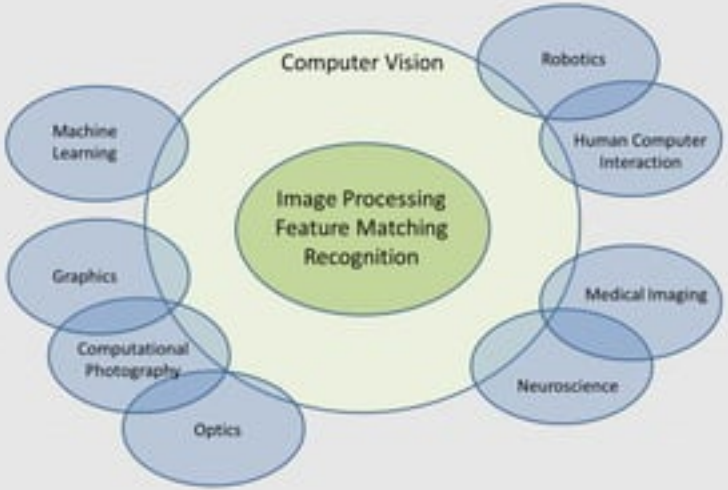
Security

Comfort

Fun

Access

Computer Vision Scope



Computer Vision Field

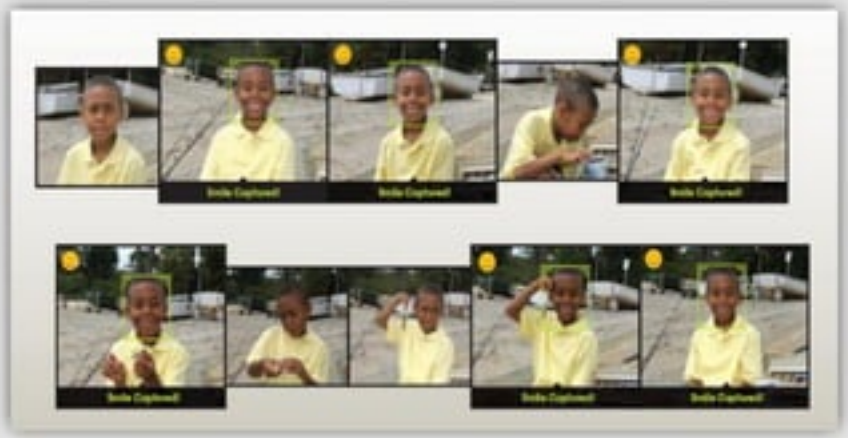
1. Optical Character Recognition (OCR):
   - Technology to convert scanned docs to text.
   - If you have a scanner, it probably came with OCR software.

Computer Vision Field

2. Face Detection:
   - Many new digital cameras now detect faces

Computer Vision Field

3. Smile Detection:



Computer Vision Field

4. Vision-based biometrics:
   - How the Afghan Girl was Identified by Her Iris Patterns



Computer Vision Field

5. Login without Password:

Fingerprint scanners on many new laptops, other devices

Face recognition systems now beginning to appear more widely
http://www.sensiblevision.com/

Computer Vision Field

6. Object Recognition:
   - In mobile phones point and find, Google goggles

Computer Vision Field

6. Object Recognition:
   - In supermarkets a smart camera is flush-mounted in the checkout lane, watching for items. When an item is detected and recognized, the cashier verifies the quantity of items that were found under the basket, and continues to close the transaction.

Computer Vision Field

7. Smart Cars:

Computer Vision Field

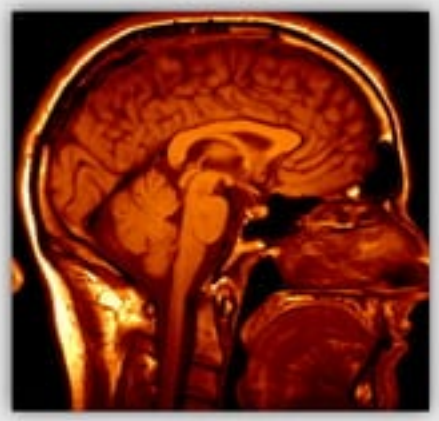
8. Interactive Games (Kinect):

Computer Vision Field

9. Industrial Robots:

Computer Vision Field

10. Medical Imaging:




STACK-ON


STACK ON

Thank You