DIGITAL IMAGE PROCESSING

CHANG SHU

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WHO – CONTACT ME

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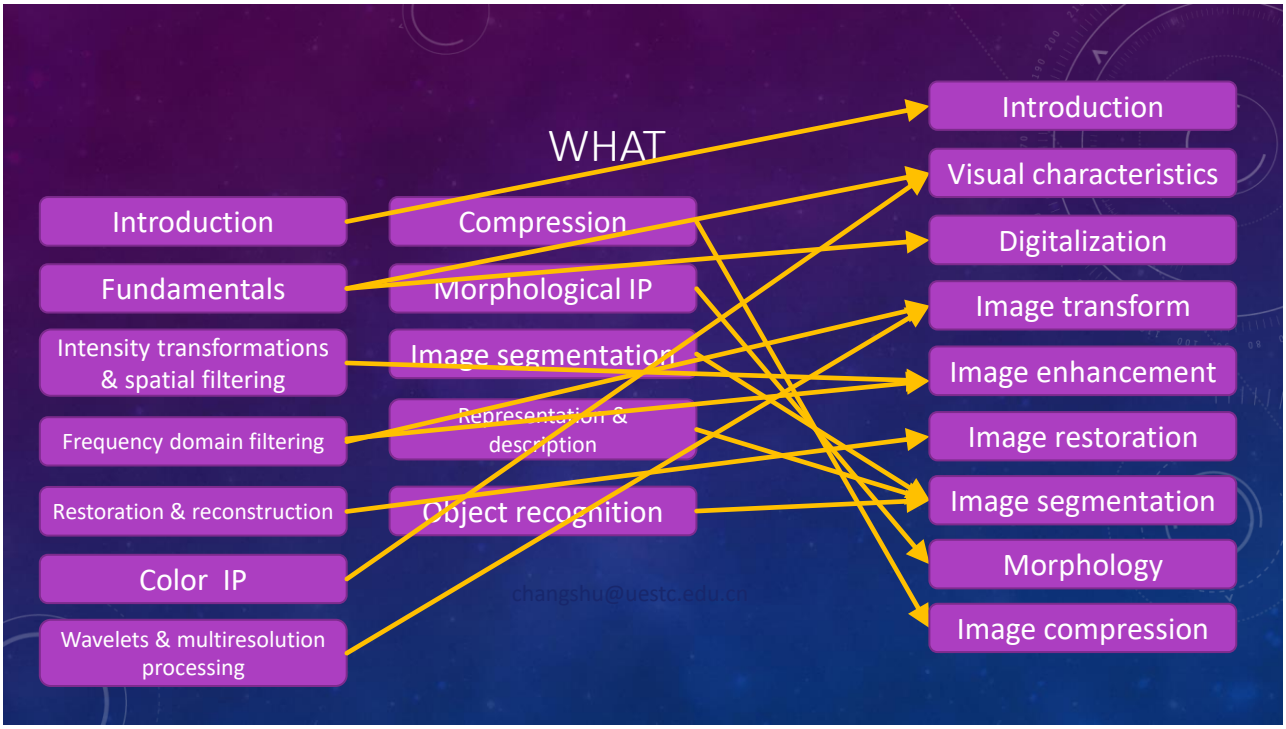
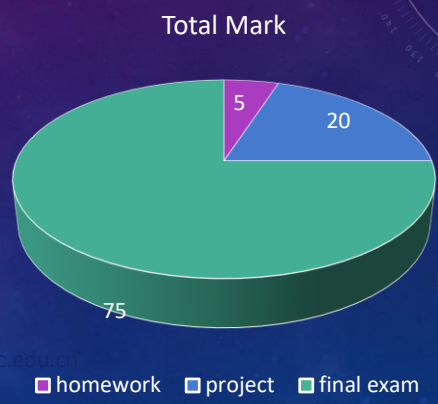


HOW

- Evaluation
  - Homework & in-class exercises
  - Project
    - Project report
    - Presentation
  - Final exam



PREREQUISITES

- Algebra:
  - Matrices/determinant, linear space, eigen value/vector, linear transform, ...
- Probability theory:
  - Independence, interdependence, conditional probability, probability distribution, random variables,...
- Signals and systems:
  - Time/frequency domain, Discrete Fourier Transform, convolution, Low Pass Filter,...

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REFERENCE

- Google， Wiki， Baidu， ……
- Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing 3rd edition）. House of Electronics Industry, 2011/2017
- Anil K. Jain. Fundamentals of Digital Image Processing(数字图像处理基础). Prentice Hall(清华大学出版社), 1989(2006)
- W.Pratt, Digital Image Processing, Third Edition, 2001

REFERENCE

- Top conferences ICCV, CVPR, ICIP, ICPR, ECCV, …
- Top journals PAMI, IJCV, TIP, PR, CVIU, …

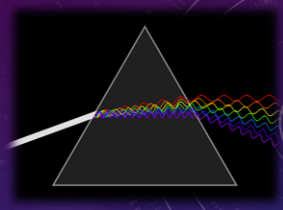
BASIC CONCEPTS

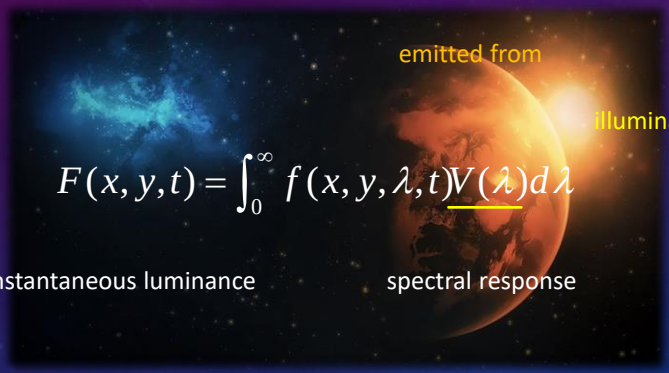
analog image

gray image

intensity response

BASIC CONCEPTS





$$I = f(x, y, \lambda, t)$$

Illuminance — luminance

Coordinates

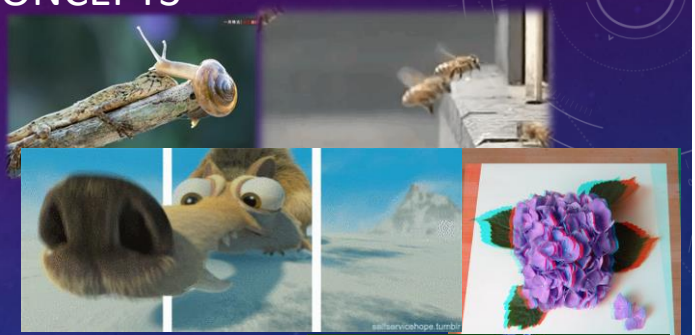
Wavelength

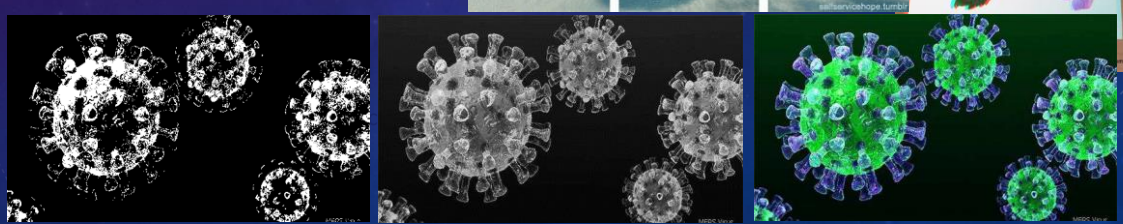
Time

- ***I*(.)** represents **the spatial energy distribution** of an image source of **radiant energy**.
- An image can be seen as a distributed amplitude of color(s).

BASIC CONCEPTS

- **Image**
  - **Still / Sequential**
  - **Analog / Digital**
  - **Two-dimensional / Three-dimensional**
  - **Binary / Gray / Color**
  -





BASIC CONCEPTS

- **Digital image (Two-dimensional)**

$$I = f(x, y, \lambda, t)$$

  - When the value of spatial coordinates and amplitude of *I* are both finite, discrete, it is called a digital image.
  - Digital images are constructed of finite elements (pixels) .
  - Each pixel has a particular location and value.

$$f(x,y) \rightarrow I(m,n)$$

$$I(m,n) = \begin{bmatrix} I(0,0) & I(0,1) & \cdots & I(0,N-1) \\ I(1,0) & I(1,1) & \cdots & I(1,N-1) \\ \vdots & & & \\ I(M-1,0) & I(M-1,1) & \cdots & I(M-1,N-1) \end{bmatrix}$$

WHAT

- **Digital Image Processing**
  - Processing digital images by means of a digital computer

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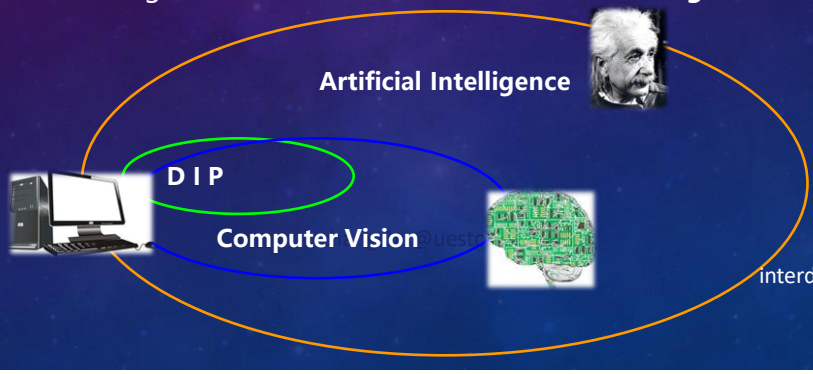
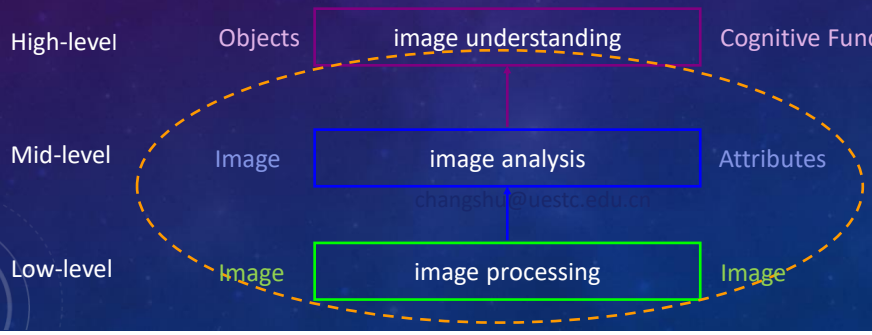
WHAT – ORIENTATION

- **Related areas**
  - Computer Vision —— **automate tasks human vision system can do**
  - Artificial Intelligence —— **automate tasks human intelligence can do**



WHAT – ORIENTATION

- **DIP domain**
  - **Narrow sense —— improvement of image quality for human interpretation, processing of image data for storage, transmission, display and representation for machine perception**
  - **Broad sense —— includes fields where image processing ends and image analysis and image understanding starts.**



DEVELOPMENT

1930s

1946

1960s

the onset of the space race

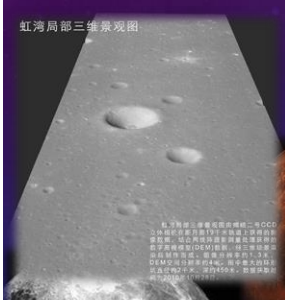
Analog image processing

DEVELOPMENT

Pluto

Saturn

Jupiter



Mars

Moon

Pictures taken by space probes

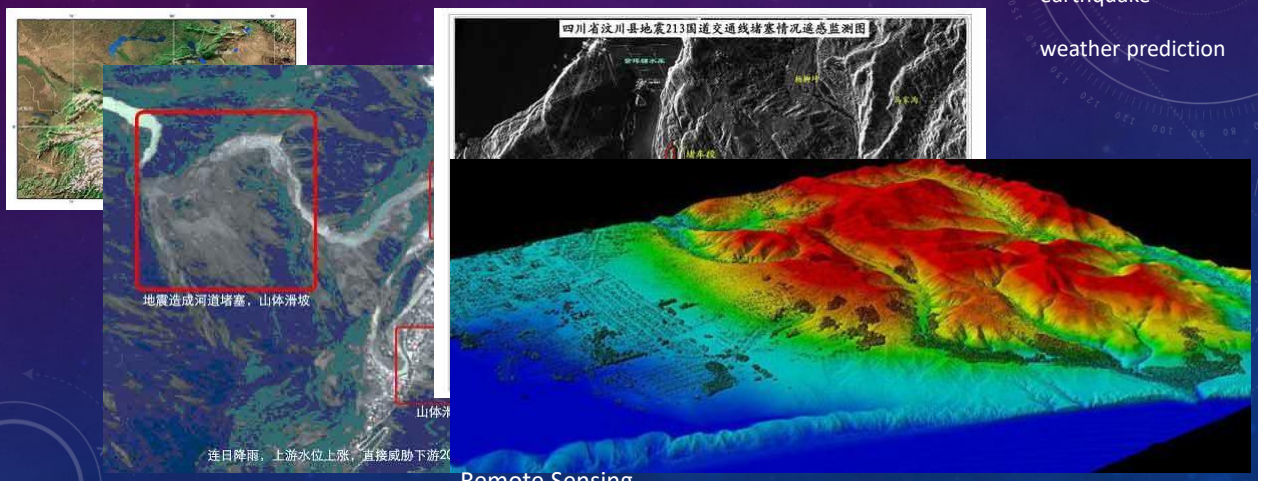
DEVELOPMENT

mining

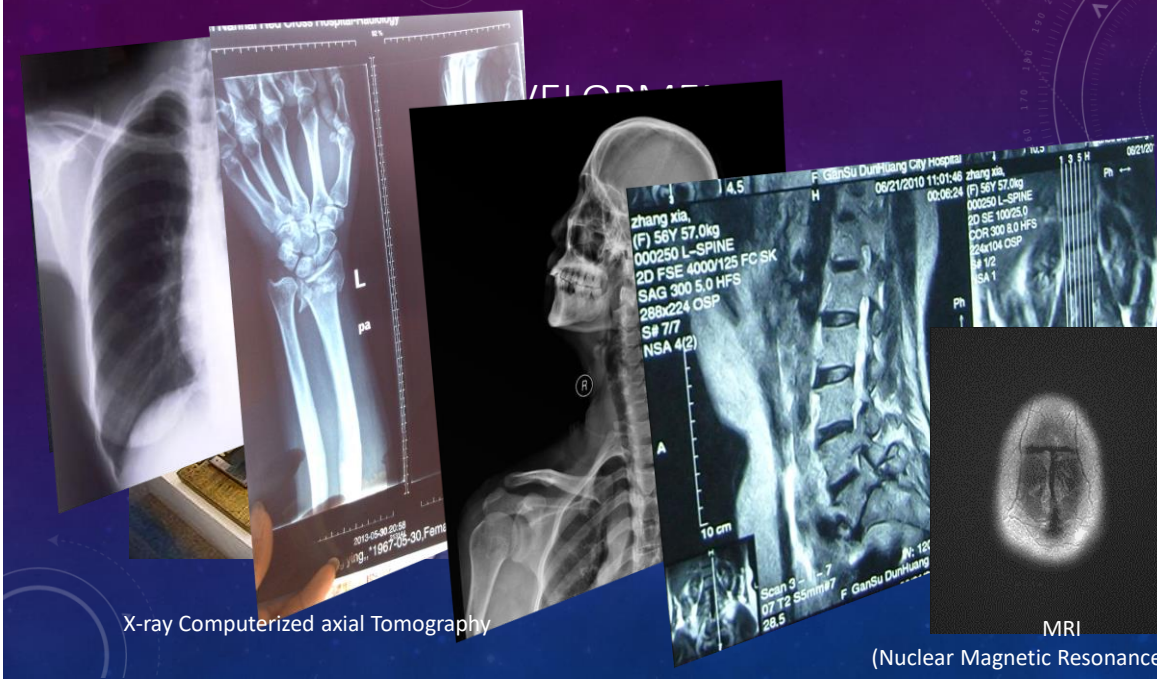
oil-gas exploration

earthquake

weather prediction



Remote Sensing



X-ray Computerized axial Tomography

MRI

(Nuclear Magnetic Resonance Imaging)

TASKS AND GOALS

Acquisition & Digitalization

Image signal processing

- Enhancement/Restoration
- Transform

Analysis & Understanding

Compression & Encoding

TASKS AND GOALS

Improve image quality

Extract target features

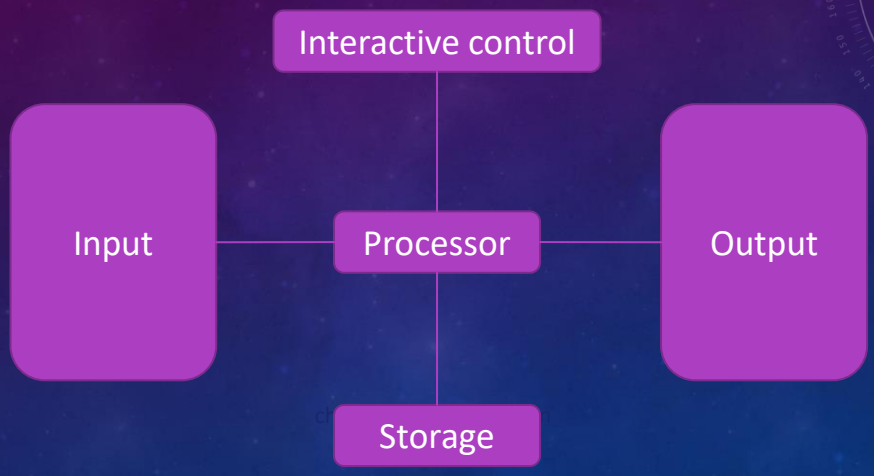
- human
- machine

Information visualization

Information security

Intellectual property protection

IMAGE PROCESSING SYSTEM



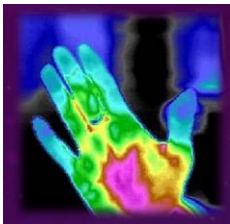


IMAGE PROCESSING SYSTEM

- **Image Input**
  - **Sensors**
    - **CCD**（Charge Coupled Device）
    - **CMOS**（**Complementary Metal-Oxide Semiconductor**）
    - **InfraRed**
  - **Ways of input**
    - **Fly-point scanning**
    - **Line sensor**
    - **2D sensor**

IMAGE PROCESSING SYSTEM

- **Image Output**
  - **Display devices**
    - **CRT**(Cathode Ray Tube)
    - **LCD**(Liquid Crystal Display)
    - **PDP**(Plasma Display Panel)
    - **DLP**(Digital Light Procession)
  - **Ways of Output**
    - **3D image**
    - **E-paper**
    - **Hardcopy**

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IMAGE PROCESSING SYSTEM

- **Image Output**
  - **Display devices**

Wearing glasses: www.terryfic3D.com

Naked eyes: www.seereal.com

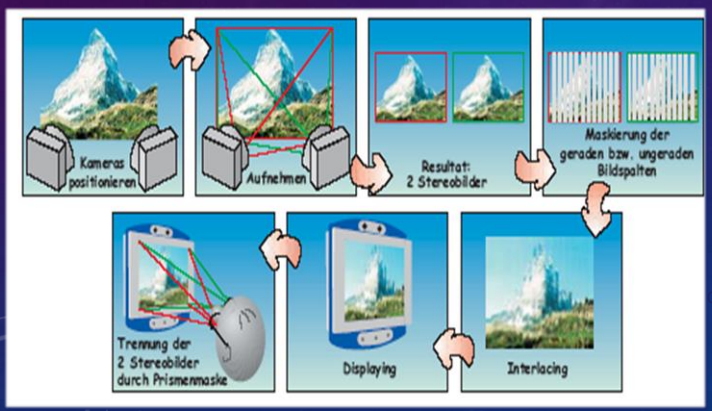
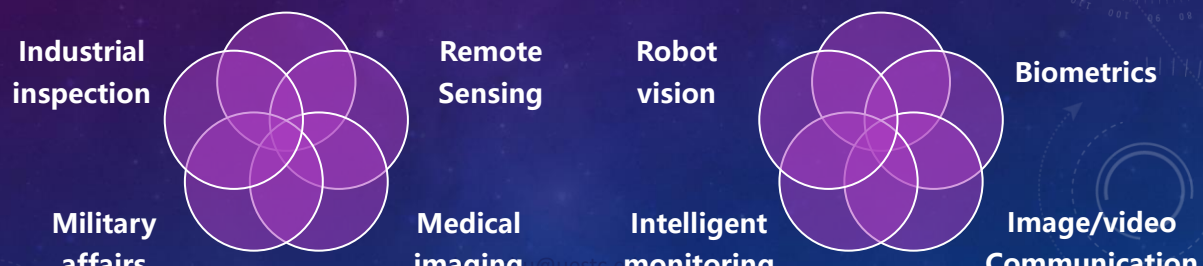


IMAGE PROCESSING SYSTEM

Photoshop
CorelDRAW
ACDSee
VC++
MATLAB IP toolbox

APPLICATION



APPLICATION-ENHANCEMENT

Image enhancement

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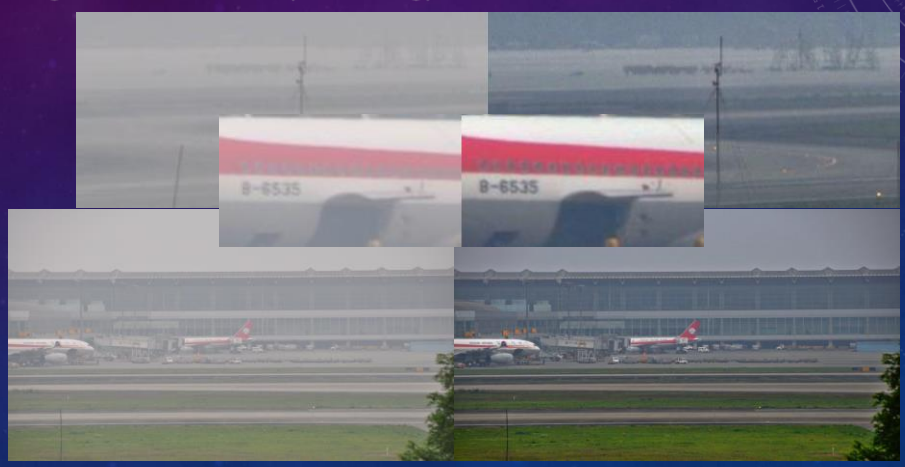
APPLICATION-ENHANCEMENT

Image enhancement(dehazing)



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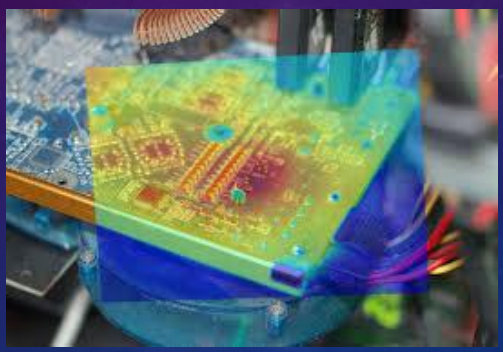
APPLICATION

Image enhancement

(over-exposure)

APPLICATION-FUSION

Image fusion



registered or matched

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APPLICATION-MATCHING

Video stablization

geometric modification

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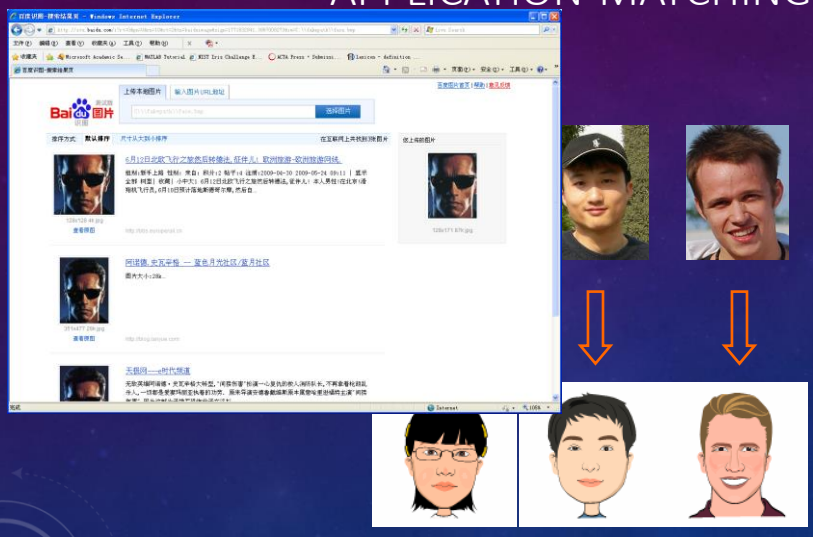
APPLICATION-MATCHING



Cartoon-making, image searching

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APPLICATION-MATCHING

E-commerce

Innodemo

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APPLICATION-MATCHING

Panorama(全景) stitching

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FOD system

(foreign object detection)

APPLICATION-DETECTION

Car Plate Detection

APPLICATION-DETECTION

Traffic sign detection

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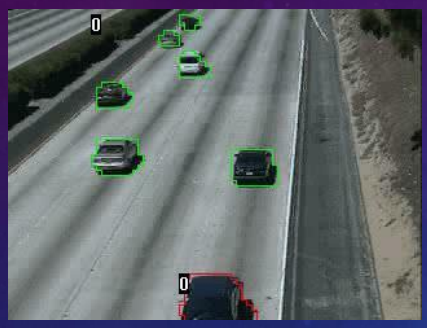
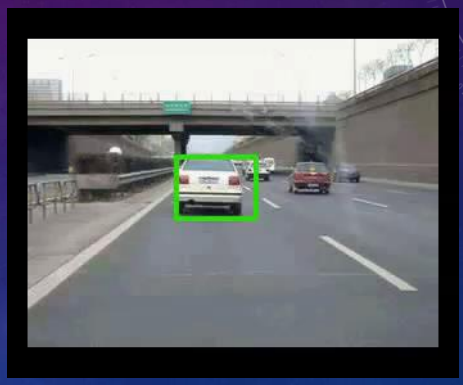
APPLICATION-DETECTION

Pedestrian detection

APPLICATION-TRACKING





Car tracking

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APPLICATION-TRACKING

Pedestrian counting

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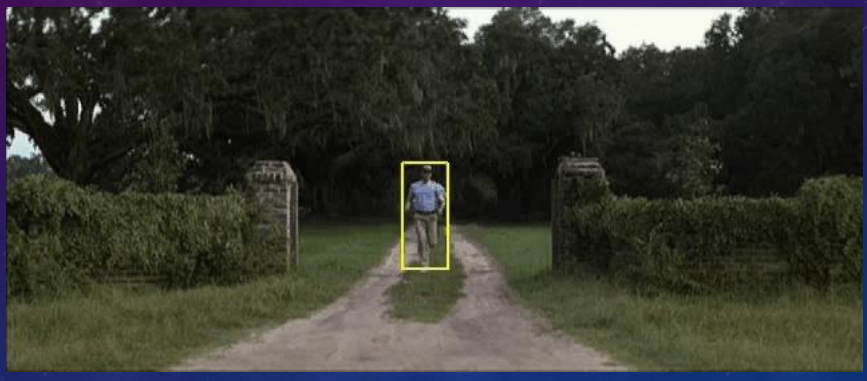
APPLICATION-TRACKING

Single target tracking



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APPLICATION-TRACKING

Multi-target tracking

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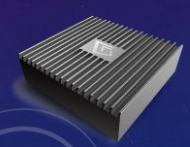
APPLICATION-RECOGNITION

PD+FR

Intelligent monitoring

APPLICATION-RECOGNITION

+



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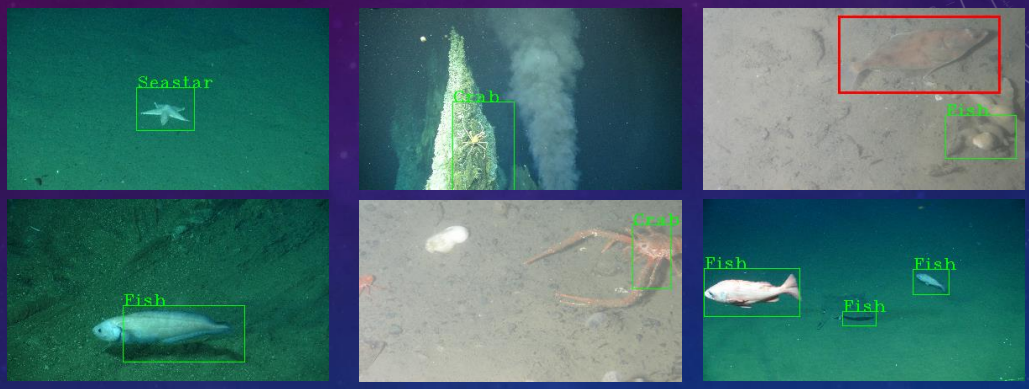
APPLICATION-RECOGNITION

Auto annotation



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APPLICATION-RECOGNITION

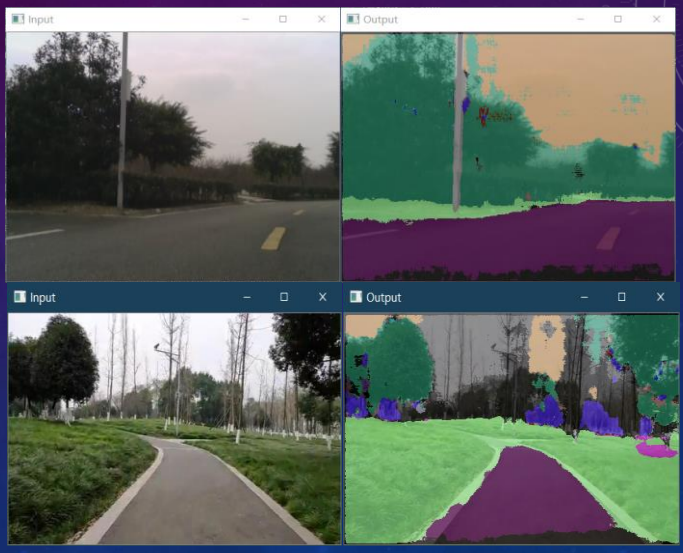

Image segmentation

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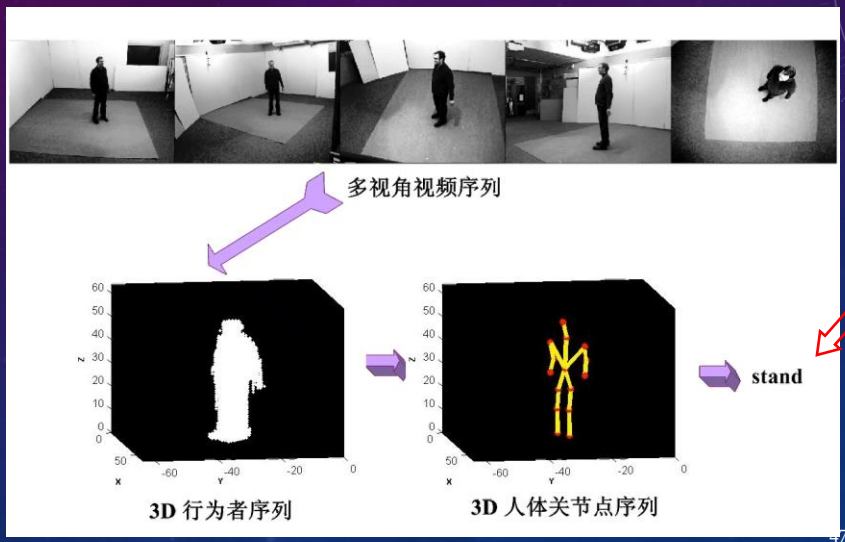
APPLICATION-RECOGNITION

Action recognition



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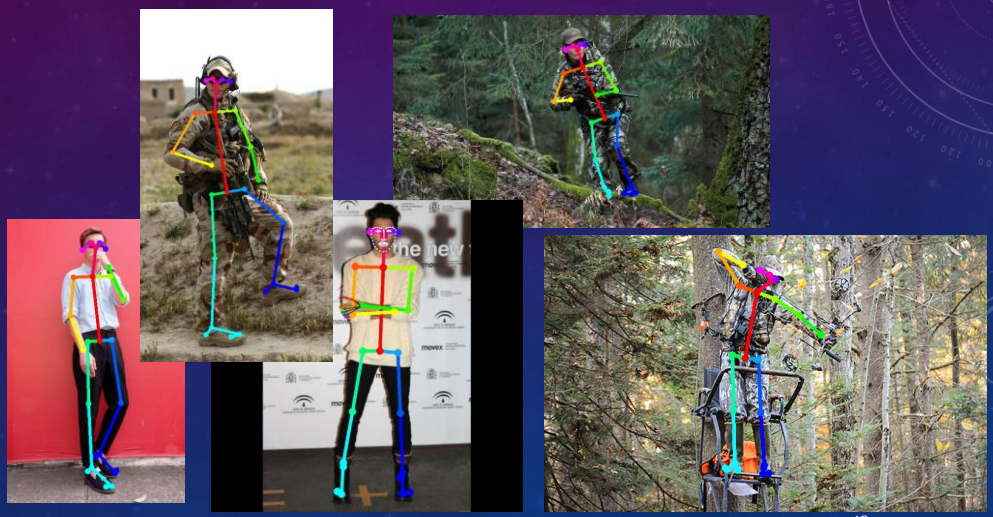
APPLICATION-RECOGNITION

Pose Estimation



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APPLICATION

Game control1

Game control2

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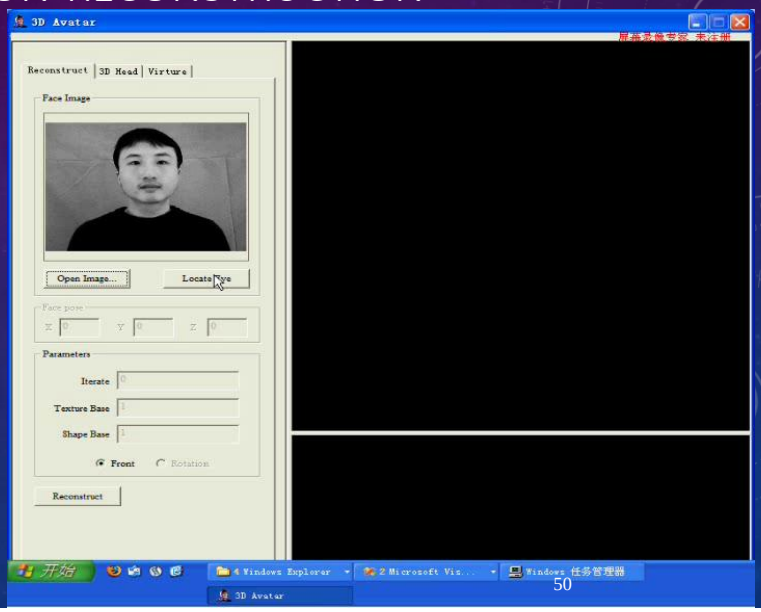
APPLICATION-RECONSTRUCTION

demoFL

demo Gaze

3D Face reconstruction



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APPLICATION-RECONSTRUCTION

Object tracking and bird-of-view map generating

SUMMARY

- Digital image/ Digital image processing
- History of digital image processing
- Components of an image processing system
- Applications of digital image processing

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