INTRODUCTION TO THE DIGITAL IMAGE PROCESSING

Lecture #1

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Professor
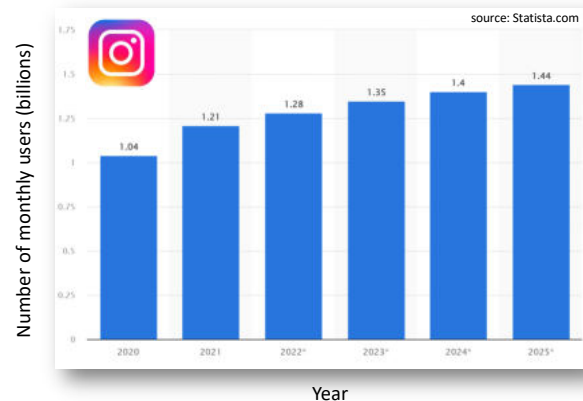
ECE Department
Department of Bioengineering
Quantitative Biosceince Program

WHY IMAGE PROCESSING?

- Humans are visual creatures
- A large amount of information enters our brain through our visual system
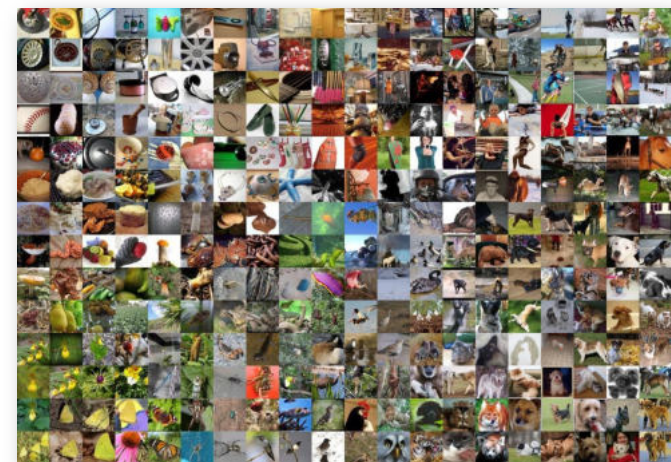- Images are very important
- Key part of our modern society…

INSTAGRAM USERS OVER TIME

The number of users has grown significantly

About 1.4 billion/month
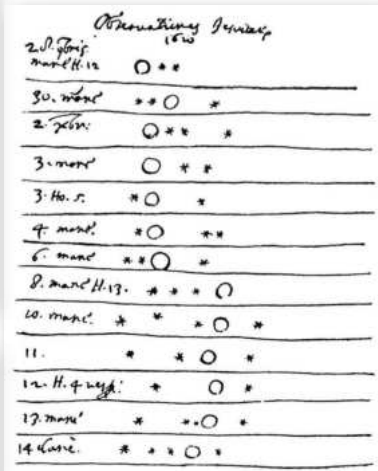

APPLICATIONS OF IMAGE PROCESSING

SCIENTIFIC EXPLORATION

Galileo with his telescope

Jupiter with moons

Galileo's notes

SCIENTIFIC EXPLORATION

NASA Spirit Mars Rover

MANUFACTURING/CONSTRUCTION

Blueprint

Render

SAFETY AND SECURITY

Firefighter cameras
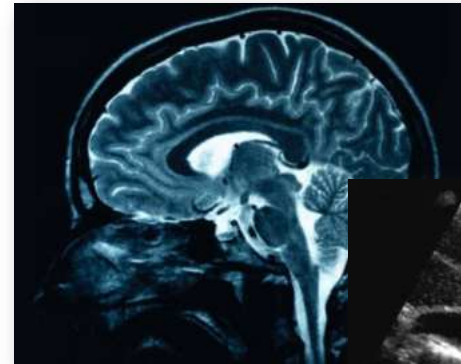

Security camera

TRAINING

Simulators
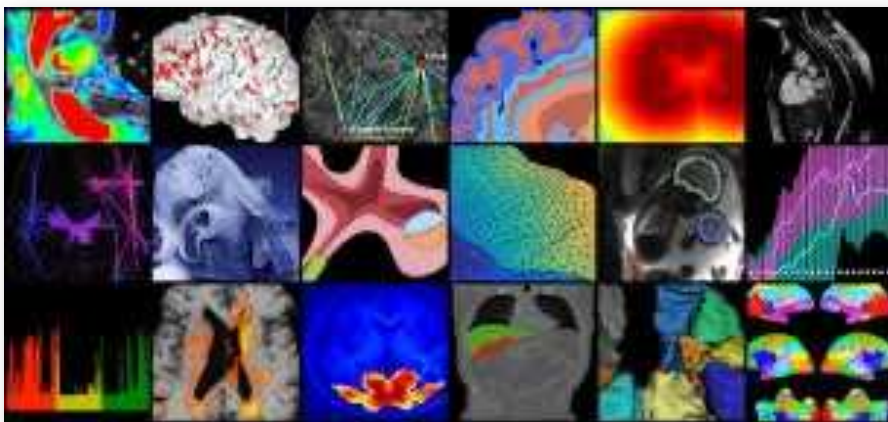

Online training

MEDICAL IMAGING

Magnetic Resonant Imaging (MRI)

Ultrasound

BIOMEDICAL RESEARCH

WHAT IS IMAGE PROCESSING GOOD FOR?

- Facilitate picture storage/transmission
  - Efficiently transmit images from a smartphone
  - Send images from Mars to Earth
- Extract information from images
  - Read the license plates on cars
  - Show doctors where the tumor is located
- Enhance or restore images
  - Remove scratches/noise from old images
  - Sharpen up a blurry image
- Prepare images for display or printing
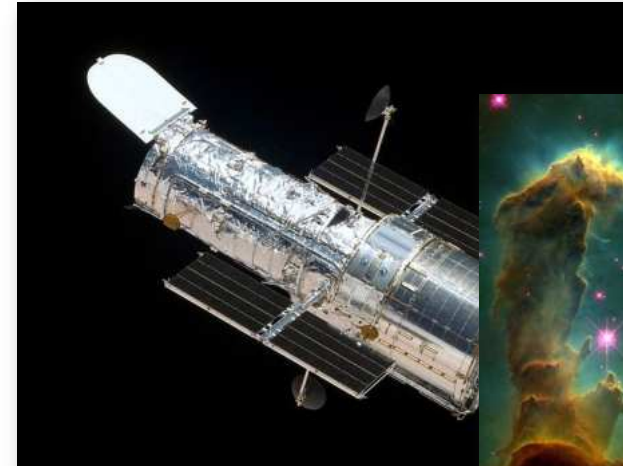
IMAGE RESTORATION

Original   Restored

CASE STUDY: HUBBLE SPACE TELESCOPE
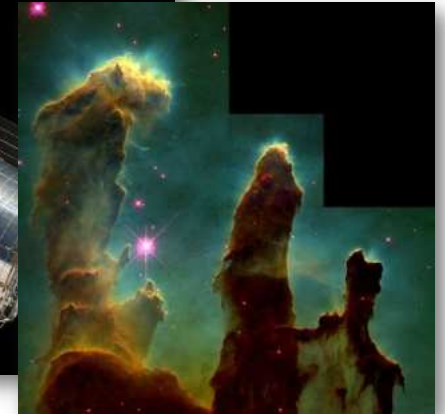

Hubble Space Telescope

Eagle Nebula

PROBLEM

- Soon after launch in 1991, NASA discovered that Hubble's optics were severely flawed due to manufacturing error

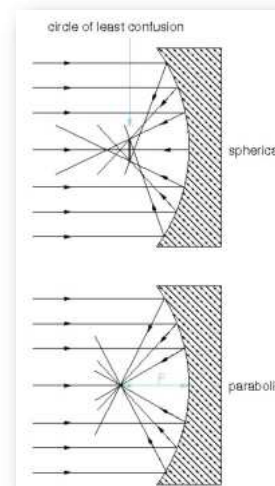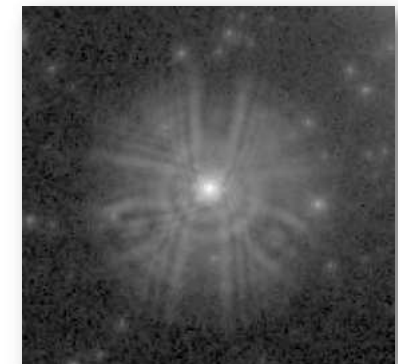- Until a repair mission in 1993, only blurry images could be acquired

HUBBLE (BEFORE 1993): SPHERICAL ABERRATIONS

Mirror was spherical instead of parabolic

Point source (a star) did not produce a point in the image but rather an intricate pattern (point spread function)

HUBBLE SPACE TELESCOPE DECONVOLUTION
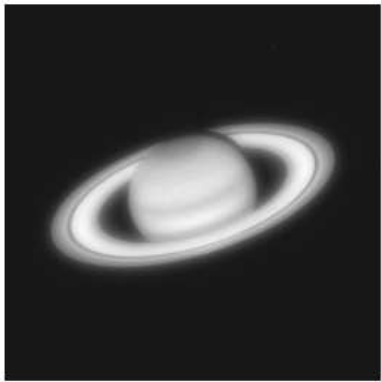### Image processing was applied to fix problem

Fig. 1: Image of Saturn as soon by the Hubble telescope before the optical correction in 1993.
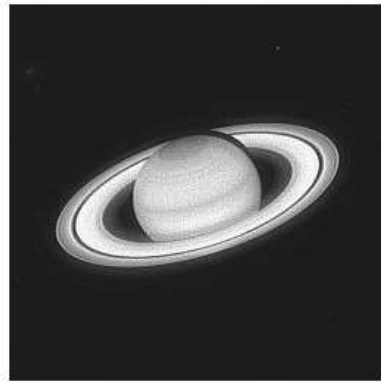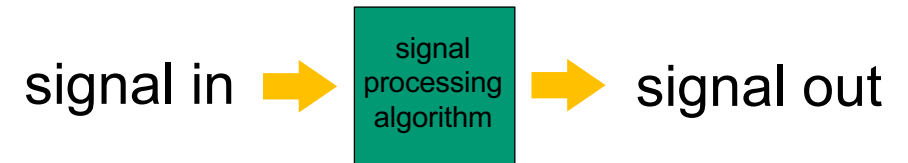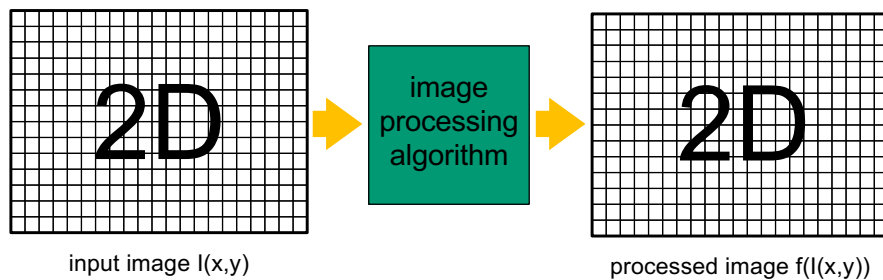
Fig. 2: The restored image after application of SeDDaRA and a pseudo-inverse filter.

WHAT IS SIGNAL PROCESSING?

signal in → [signal processing algorithm] → signal out

Images are Signals too

TRADITIONAL IMAGE PROCESSING
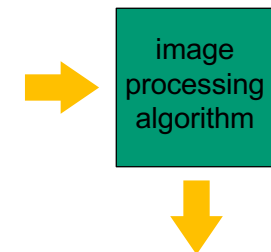
2D → [image processing algorithm] → 2D

input image I(x,y)   processed image f(I(x,y))

EXAMPLES OF IMAGE PROCESSING

Image IN: I(x,y) → [image processing algorithm]

Image OUT: -I(x,y)

EXAMPLES OF IMAGE PROCESSING

Image IN: I(x,y)

image processing algorithm

Image OUT: I(-x,-y)

EXAMPLES OF IMAGE PROCESSING

Image IN: I(x,y)

image processing algorithm

Image OUT: I(f(x,y),g(x,y))
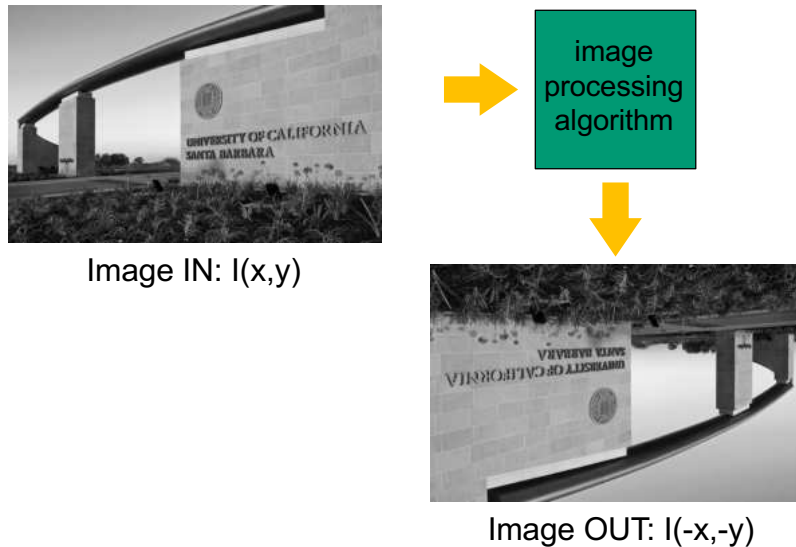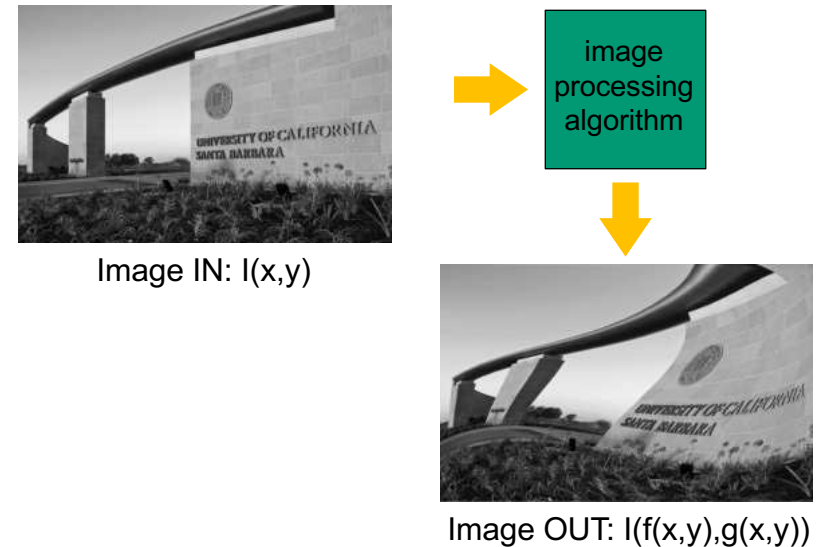
TRADITIONAL IMAGE PROCESSING

- Based on signal processing:
  - Fourier analysis
  - Filtering kernels
  - Denoising algorithms
  - Deconvolution algorithms for ill-posed problems

Claude Shannon

THIS IS THE BULK OF THIS CLASS

TRADITIONAL IMAGE PROCESSING