Week 1 (October 1, 2007):
- Course Introduction and Announcements
- Intelligent Robots as Intelligent Systems
- A systems perspective of Intelligent Robots and capabilities
- Architecture and modules
- Examples of Computer Vision systems and Intelligent "Robotica".

Intelligent Systems = "Intelligent" + "Systems"

Need to understand what these terms mean.

Examples of Intelligent Systems:
- Ant?
- Bird?
- Dog?
- Human - SURE.

Artificial intelligence - the branch of computer science that deals with writing computer programs that can solve problems creatively. "Researchers in AI hope to imitate or duplicate intelligence in computers and robots." Synonyms: AI

http://www.webster-dictionary.org/definition/artificial%20intelligence

Artificial intelligence, also known as machine intelligence, is defined as intelligence exhibited by anything manufactured (i.e. artificial). It is usually hypothetically applied to general-purpose computing. The term is also used to refer to the field of scientific investigation into the plausibility of and approaches to creating such systems.

http://en.wikipedia.org/wiki/Artificial_intelligence
Artificial intelligence includes:
- Games playing: programming computers to play games such as chess and checkers
- Expert systems: programming computers to make decisions in real-life situations (for example, some expert systems help doctors diagnose diseases based on symptoms)
- Natural language: programming computers to understand natural human languages
- Robotics: programming computers to see and hear and react to other sensory stimuli

In practical usage, a robot is a mechanical device which performs automated tasks, either according to direct human supervision, a pre-defined program or a set of general guidelines, using (artificial intelligence) techniques. These tasks either replace or enhance human work, such as in manufacturing, construction, or manipulation of heavy or hazardous materials.

A robot may include a feedback-driven connection between sense and action, not under direct human control. The action may take the form of electro-magnetic motors or actuators that move an arm, open and close grips, or propel the robot. The step by step control and feedback is provided by a computer program run on either an external or embedded computer or a microcontroller. By this definition, a robot may include nearly all automated devices.
Intelligent Systems: Introduction

Evolution of Robots:
- Pre 1970: Robots as novelty, specialized toys, teleoperation
- 1970: Preprogrammed robots
- 1985: Sensor-based “intelligent” robots
- 1995: Cooperative robots, “virtual” and “real” robots
- 2000: Intelligent environments, “Sociable” robots

ECE 172A: Intelligent Systems: Introduction

Week 1 (October 3, 2007):
- Course Introduction and Announcements
- Intelligent Robots as Intelligent Systems
- A systems perspective of Intelligent Robots and capabilities
- Architecture and modules
- Examples of Computer Vision systems and Intelligent “Robotics”

Assignments (Reading, Viewing and Comments):
- Sensor-Based Intelligent Robots (IEEE Trans. SMC’95 Paper)
- Intelligent Environments (IEEE Trans SMC’05 paper)

It is a multipurpose device or a manipulator which (can be programmed to) perform a variety of tasks (1980-1995)
Robot can be viewed as the Physical link between intelligence and Action.
Intelligent Environments can:
- Develop and maintain awareness of events
- Adapt to the dynamic changes in their surroundings
- Interact in a natural, efficient and flexible manner with the users

Key Features:
- Apply different types of camera arrays to provide multiple signal-level resolutions.
- Ability to derive semantic information at multiple levels of abstraction.
- Ability to be "attentive" to specific events and activities.
- Ability to actively shift the focus of attention at different "semantic" resolutions.

Types of interactions:
- between active participants – people present in the room
- between the "Room" and remote participants
- between the "Room" and "future" participants
Intelligent Spaces: Indoor

AVIARY: Audio-Video Interactive Appliances, Rooms, and Systems

Intelligent Robots and Vision Systems: Video Demos/Samplings

- IEEE Computus-88 (introducing sensor-based robots)
- CVRR 1994 Clips (integrated sensing, planning, mobility, Cooperating robots)
- AVIARY 2000 (Intelligent Environments)
- Mobile Video Probes 1998 (Human-machine Cooperation)
- Androids 2006

ECE 172A: Intelligent Systems: Introduction

Week 1 (October 3, 2007)

- Course Introduction and Announcements
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- Architecture and modules
- Examples of Computer Vision systems and Intelligent "Robotics".

Assignments (Reading, Viewing and Comments):
- Sensor-Based Intelligent Robots (IEEE Trans. SMC'95 Paper)
- Intelligent Environments (IEEE Trans SMC'05 Paper)
Intelligent Systems: Introduction

“Intelligent” Robots

Perception
Planning/ Control
Motor
Learning

Vision System

Types of Intelligent Systems:
- Biological (Human)
- Artificial
- How about hybrid?

Intelligent Systems: Levels of Autonomy

Manual

Full Autonomy

Level of Autonomy needs to be properly selected for all four key elements of an I.S.:
- Perception
- Planning
- Action
- Learning

Intelligent Systems: Example of Autonomous Robot
Outline (October 10, 2007):

- What is computer vision?
- Relationship with sister disciplines:
  1) Image Processing,
  2) Pattern Recognition
  3) Computer Graphics
- What is role of computer vision in Intelligent Systems?
- What are Computer Vision Systems good for?
- Examples of Computer Vision systems for Intelligent Environments.

Reading Assignment:
- Chapter 1 and 2 (Text book)
- Encyclopedia Article (Class web)
Computer Vision: Introduction

Computer Vision and "sister" disciplines:

**Image Processing**
- **Input:** Image
- **Output:** Image

**Pattern Recognition**
- **Input:** Measurement Vector
- **Output:** "Classified Vectors"
- **Examples:**
  - Male/Female
  - Biomedical
  - Land-use classification
  - Face Recognition

Applications:
- Image Enhancement
- Noise Filtering
- Image Compression
Computer Vision: Introduction

Computer Vision and "sister" disciplines:

Input:
1. Image Derived Measurements
2. "Models": Prior knowledge about Imaging, Application Domain, and other useful information

Output: Recognition of Objects and Events embedded in Images and Video ("Semantic" level Classification)

Examples:
- Object Recognition
- Face recognition
- Lane detection
- Activity analysis

Computer Vision Examples: Intelligent Robotics

- Localization of the Panel—corner lights
- Meter Reading
- Spill detection
- Spill Localization
- Tool Detection and Localization
- Spill clean-up Verification
-...

Multiple Abstractions

Simultaneous 3D tracking of multiple blobs

Face orientation estimation

Event of "interesting" scenes

Affect Analysis

IMR Video
Computer Vision in Intelligent Vehicles

Looking Out:
- Vehicle in Front
- Obstacles
- Lanes and Guard Rails
- Pedestrians
- Road Signs
- 

Looking In:
- Occupant Position and Posture
- Driver Head Pose
- Driver Eye Gaze
- Driver Body Pose and Gestures
- 

Computer Vision in Intelligent Transportation Systems

- Traffic Flow
- Traffic Types, Vehicle Classification
- Lane utilization and Efficiency
- Incidents
- Pedestrian Crossings
- Infrastructure Health and Safety
- Public Safety
- 

Computer Vision: Introduction

Computer Vision and "sister" disciplines:

Output:
-Images ("synthesized")

Input:
Mathematical Model of Objects and Events

Examples:
- Driving Simulation
- Virtual "Tours"
- Video Games
- Animated Models for Education

Computer Graphics
Computer Vision: Introduction

Computer Vision and "sister" disciplines:

Examples:
- Driving Simulation
- Virtual "Tours"
- Video Games
- Animated Models for Education

Input:
1. Image Derived Measurements
2. "Models":
Prior knowledge about Imaging, Application Domain, and other useful information

Output:
Recognition of Objects and Events embedded in Images and Video ("Semantic" level Classification)

Examples:
- Object Recognition
- Face recognition
- Lane detection
- Activity analysis

Vision is Signal to Symbol Transformation

Input: Signals

Output: Symbols

Examples:
- Object Recognition
- Face recognition
- Lane detection
- Activity analysis

Vision

Computer Vision

Examples:
- Object Recognition
- Face recognition
- Lane detection
- Activity analysis
When the perturbations of the psychic nature have all been stilled, then the
consciousness, like a pure mirror, takes the color of what it sees, or, whether
that be the perceiver, perceiving, or the thing perceived.

When the consciousness, poised in perceiving, blends together the name, the object
dwelt on and the idea, this is perception with exterior considerations.

When the object dwells in the mind, clear of memory-pictures, uncoloured by the
mind, as a pure luminous idea, this is perception without exterior or consideration.

Patanjali
Visual Arts: How to make Waldo "pop-out"?

- Color
- Texture
- Size
- Orientation
- Contrast
- Texture

Anatomy, Ophthalmology

- Iris
- Pupil
- Sclera

http://www.stlukeseye.com/Anatomy.asp

Neuroscience and Vision

- Retina Ganglion Cells: receive visual information, not anatomical interfaces, not visual information transmission
- Lateral geniculate: structurally and functionally complex, but not responsible for visual information transmission
- Visual Cortex: here we find the actual visual processing, including orientation, color, and spatial information discrimination

http://ruccs.rutgers.edu/~blaser/Lecture10.html
Perception, especially "pre-attentive," is governed by Gestalt Principles. Important Gestalt Principles include:

- Proximity
- Similarity
- Uniformity or homogeneity
- Closure
- Good Continuation
Integrated Testbed for Eye Movement Studies (ITEMS)

A Framework for Perceptual Experiments

A Psychophysical Experiment using ITEMS
Project Chameleon: Texture Synthesis


Computer Vision: Introduction

Outline (October 15, 2007):
- Systematic Approach to Building Computer Vision Systems
- Computational Hierarchy of Vision
  - Model-Based Vision
  - Low-, Mid-(intermediate), and High-Level Vision
  - Active Vision
- Image Capture and Cameras (Chapter 2 Gonzalez and Wintz)

Computer Vision: Introduction

Science and Engineering of Vision

- Visual Arts
- Anatomy
- Neuroscience
- Perceptual Psychology
- Cognitive Science
- Computer Science and Engineering
Computer Vision: Introduction

Vision is Signal to Symbol Transformation

Input: Signals

Output: Symbols

Examples:
- Object Recognition
- Face recognition
- Lane detection
- Activity analysis

What is Perception?

“To see an object in the world we must see it as something”

(S. Wittgenstein)

Model Based Grouping
Abstraction Hierarchy in Vision

- Signals
- Images and Image Streams
- Contrast, Segments, Color, Texture, Depth, Motion
- Symbols
- Objects and Events
- Pre-attentive Cues

Perception: Gestalt Principles

Perception, especially "pre-attentive", is governed by Gestalt Principles:

Important Gestalt Principles include:

- Proximity
- Similarity
- Uniformity or homogeneity
- Closure
- Good Continuation

Computational Vision Hierarchy

- High-Level Processing
  - Relational Structure Analysis, Matching, Object/Event Recognition, Scene Interpretation
- Intermediate (Mid) Level Processing
  - Image Analysis: 3D Feature Detection (including Depth and Motion Analysis)
- Low Level Processing
  - Image Processing (including Enhancement, coding, filtering tasks) and 2D Feature Detection and Analysis (including edge/region/contour analysis, segmentation)

3D, Dynamic Scene
Two Stage Processing in Vision and "Active Vision"

Stage 1: Bottom-up
- Pre-attentive Processes
  - Sensing
  - Pre-attentive Cues: Contrast, Color, Texture, Depth, Motion

Stage 2: Top-Down
- Attendive Processes
  - Memory
  - Attentive Processes
  - Feedback Control
    - Focus of attention
    - Where to look?
    - How to look?
  - Pre-attentive Cues: Feature Detection, Segmentation, Figure-ground Separation

Active Vision: Sensor-Motor Integration

- Learning
- Planning/Control
- Perception
- Motor

Active Vision: Sensor-Motor Integration

Perception

Learning

Planning/Control

Motor

Active Vision: Sensor-Motor Integration

Human Vision

- Eyes must make control eye movements
  - Smooth pursuit
  - Saccades

University of Florida, Gainesville
Active Vision: Sensor-Motor Integration

2-D Image and 3-D World

Physical and geometric processes that govern (digital) imaging

P' is the projection of P

2-D Image Plane

3-D World
How Cameras Produce Images?

Basic Process:
- Light (photons) hit a detector
- Detector is "charged"
- Amount of charge is "read" as brightness

Camera Vision: Introduction

Outline (October 17, 2007):
- Image Representation (Chapter 2 Gonzalez and Woods)
- Low Level Vision Image Processing (Chapter 3 Textbook)
  - Spatial and Transform (Frequency) Domains
  - Image Enhancement - Image Restoration
  - Spatial Domain: Point, Region, Histogram Based Approaches
- Frequency Domain Approaches
- Examples of Image Processing

A Digital Camera: IP System

Camera Digitizer Computer

Analog Signal Digital Signal

DISPLAY
How Cameras Produce Images?

1975 Birth of a Digital Camera

Steven Sasson and 8 lb, 0.01 MB Camera

Digital Cameras
How Cameras Produce Images?

Imaging Sensor Technologies

www.tasi.ac.uk/advice/creating/camera.html
How Cameras Produce Images?

- Basic process:
  - Photons hit a detector
  - The detector becomes charged
  - The charge is read out as brightness

- Sensor types:
  - CCD (charge-coupled device)
    - Most common
    - High sensitivity
    - High power
    - Cannot be individually addressed
    - Blooming
  - CMOS
    - Simple to fabricate (cheap)
    - Lower sensitivity, lower power
    - Can be individually addressed

What is a Digital Picture?

- Digital ➔ Discrete
  - Consisting of distinct or unconnected elements
Each pixel is a measure of the brightness (intensity of light) that falls on an area of an sensor (typically a CCD chip).
Sampling and Quantization

Digital Image: Matrix and Picture Function

FIGURE 2.18
(a) Image plotted as a surface.
(b) Image displayed as a visual intensity array.
(c) Image shown as a 2-D numerical array (0, 5, and 1 represent black, gray, and white, respectively).
FIGURE 3.36 (a) Arrangement of pixels (b) pixels that are 8-adjacent (shown dashed) to the center pixel (c) 4-adjacency.

FIGURE 3.4 A 4-neighborhood (pixel a point (x, y) in an image...)
Frames are acquired at 30Hz (NTSC)

Frames are composed of two fields consisting of the even and odd rows of a frame

- Binary: $640 \times 480 \times 30 \times 9.2 \text{ Mbits/second}$
- Grey: $640 \times 480 \times 30 \times 9.2 \text{ Mbytes/second}$
- Color: $640 \times 480 \times 30 \times 27.6 \text{ Mbytes/second}$ (actually about 37 Mbytes/sec)

Typical operation: $3 \times 3$ convolution
- $9 \times 9$ multiplies + $9 \times 9$ adds $\Rightarrow 180 \text{ Mflops}$

Today’s PCs are capable of processing images at frame rate

Two Domains: Spatial and Transform

Images can be processed and analyzed in two different domains:

1) **Spatial Domain**: Image processing is accomplished directly in the Spatial ($X,Y,Z,$ and $T$) domain.

2) **Transform “Frequency” Domain**: In this, images are “transformed” from the original spatial domain to some other domain, and properties of images are examined and processed this domain. Once the processing is done, the images are “converted” back in the spatial domain.
Visualizing "Spatial Frequency" in Images

Outline (October 29, 2007):
- Low Level Vision Image Processing
  (Chapters 3 Textbook; Examples from Gonzalez and Woods website)
- Motivations for Enhancement and Restoration: Degradation and Noise
- Image Enhancement - Image Restoration
- Spatial Domain: Point, Region, Histogram Based Approaches

Also, The Hypermedia Image Processing Reference from University of Edinburgh:
http://www.cee.hw.ac.uk/hipr/html