CPSC 425: Computer Vision
(Jan-April 2007)

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Prerequisites: ***4th year ability in CPSC***

Math 200 (Calculus III)

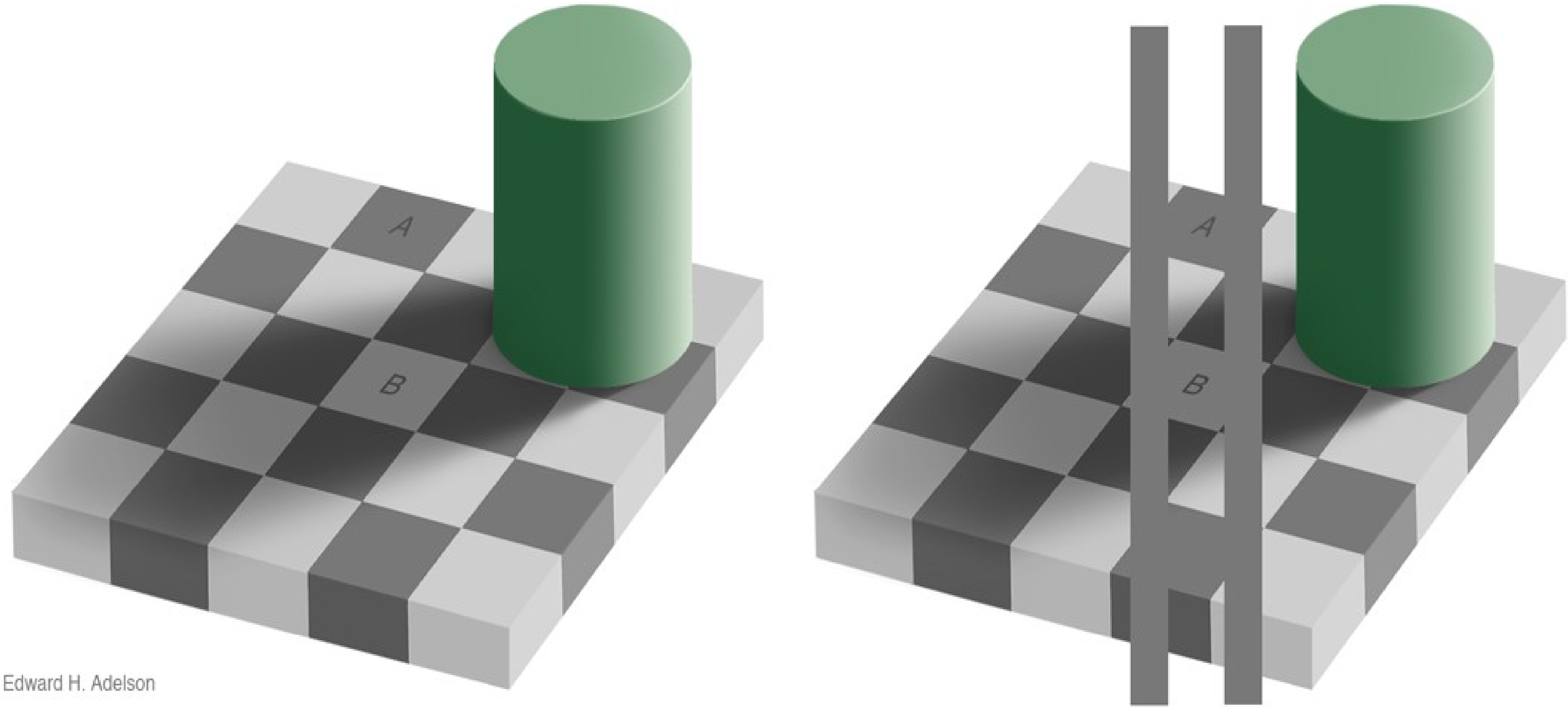
Math 221 (Matrix Algebra: linear systems)

Useful: Numerical analysis

Why study Computer Vision?

- Images and video are everywhere
- Fast-growing collection of useful applications
  - matching and modifying images from digital cameras
  - film special effects and post-processing
  - building representations of the 3D world from pictures
  - medical imaging, household robots, security, traffic control, cell phone location, face finding, video game interfaces, ...
- Various deep and attractive scientific mysteries
  - what can we know from an image?
  - how does object recognition work?
- Greater understanding of human vision and the brain
  - about 25% of the human brain is devoted to vision

Vision is inferential: Illumination



http://web.mit.edu/persci/people/adelson/checkershadow_illusion.html

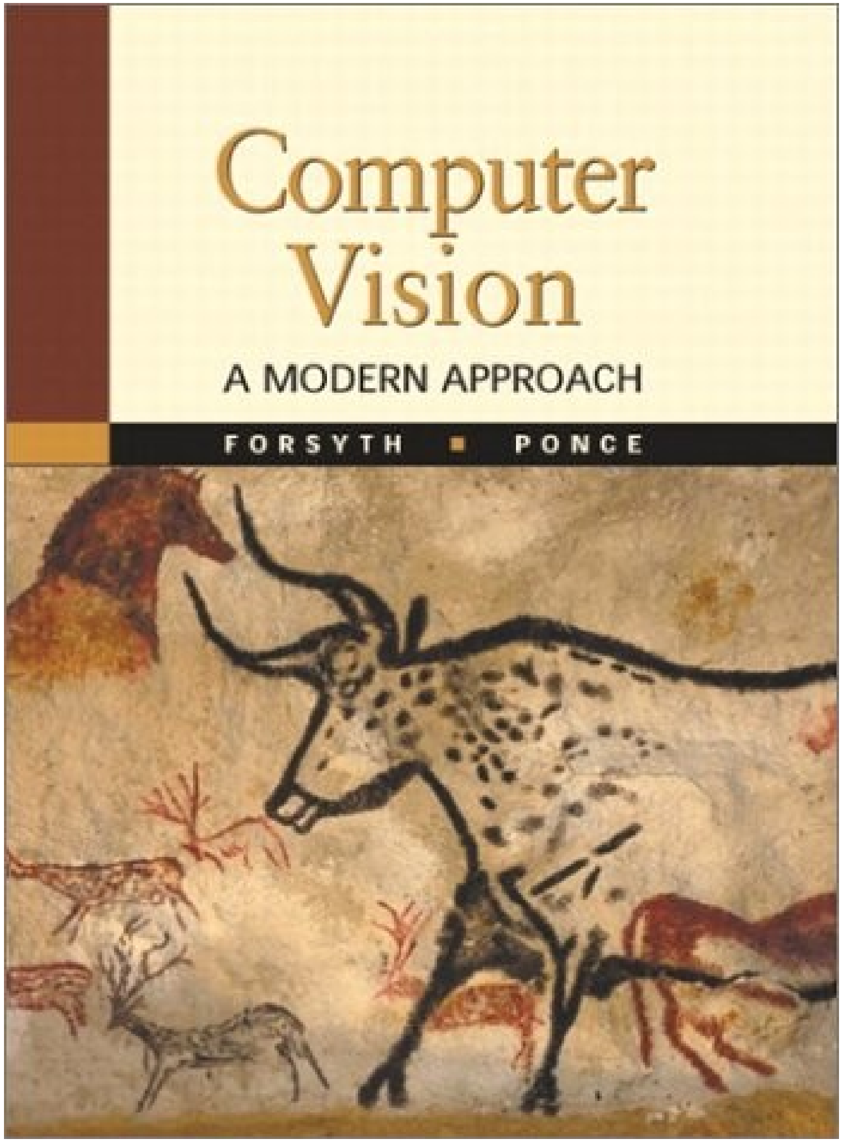
- **Course requirements**
  - 4 to 5 homework assignments (Matlab and written exercises) [25% of final mark]
  - Midterm exam (75 minutes, during class) [25%]
  - Final exam (2.5 hours, scheduled by the registrar) [50%]

- **My expectations**
  - Read assigned textbook sections and readings in advance
  - Ask questions
  - Complete all assignments on time
  - Never claim credit for work done by others

Textbook

Computer Vision by Forsyth and Ponce

- Available in the bookstore now
- Readings will be assigned with each class
- Only one edition is available, so second-hand copies are fine



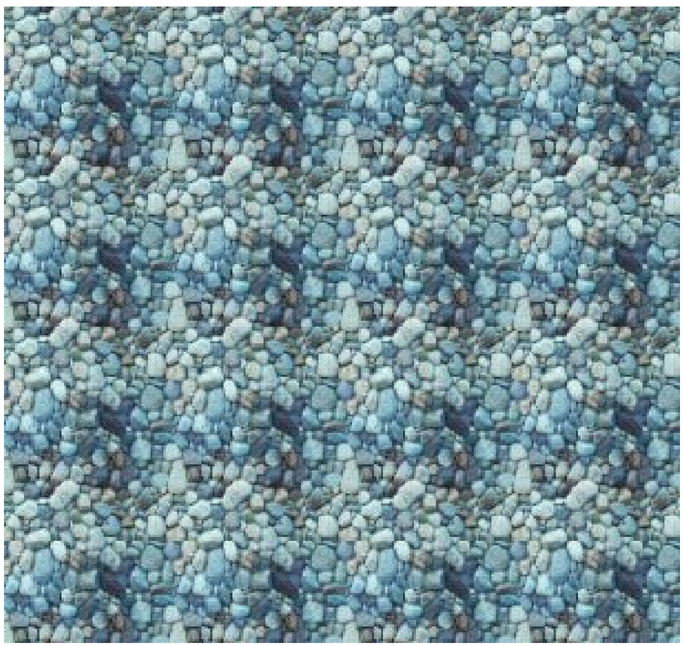
Reading for next class:

Chapter 1

Applications of Computer Vision: Texture generation

Input image

Simple repetition



New texture generated from input

We will do this for a homework assignment

Application: Football first-down line

www.sportvision.com

Requires (1) accurate camera registration; (2) a model for distinguishing foreground from background

Application: Augmented Reality

Application areas:

- Film production (the “match move” problem)
- Heads-up display for cars
- Tourism
- Architecture
- Training

Technical challenges:

- Recognition of scene
- Accurate sub-pixel 3-D pose
- Real-time, low latency

Application: Medical augmented Reality

Visually guided surgery: recognition and registration

Application: Automobile navigation

Lane departure warning

Pedestrian detection

Mobileye (see mobileye.com)

- Other applications: intelligent cruise control, lane change assist, collision mitigation
- Systems already used in trucks and high-end cars

Course Overview

Part I: The Physics of Imaging

- How images are formed
  - Cameras
    - What a camera does
    - How to tell where the camera was (pose)
  - Light
    - How to measure light
    - What light does at surfaces
    - How the brightness values we see in cameras are determined

Course Overview
Part II: Early Vision in One Image

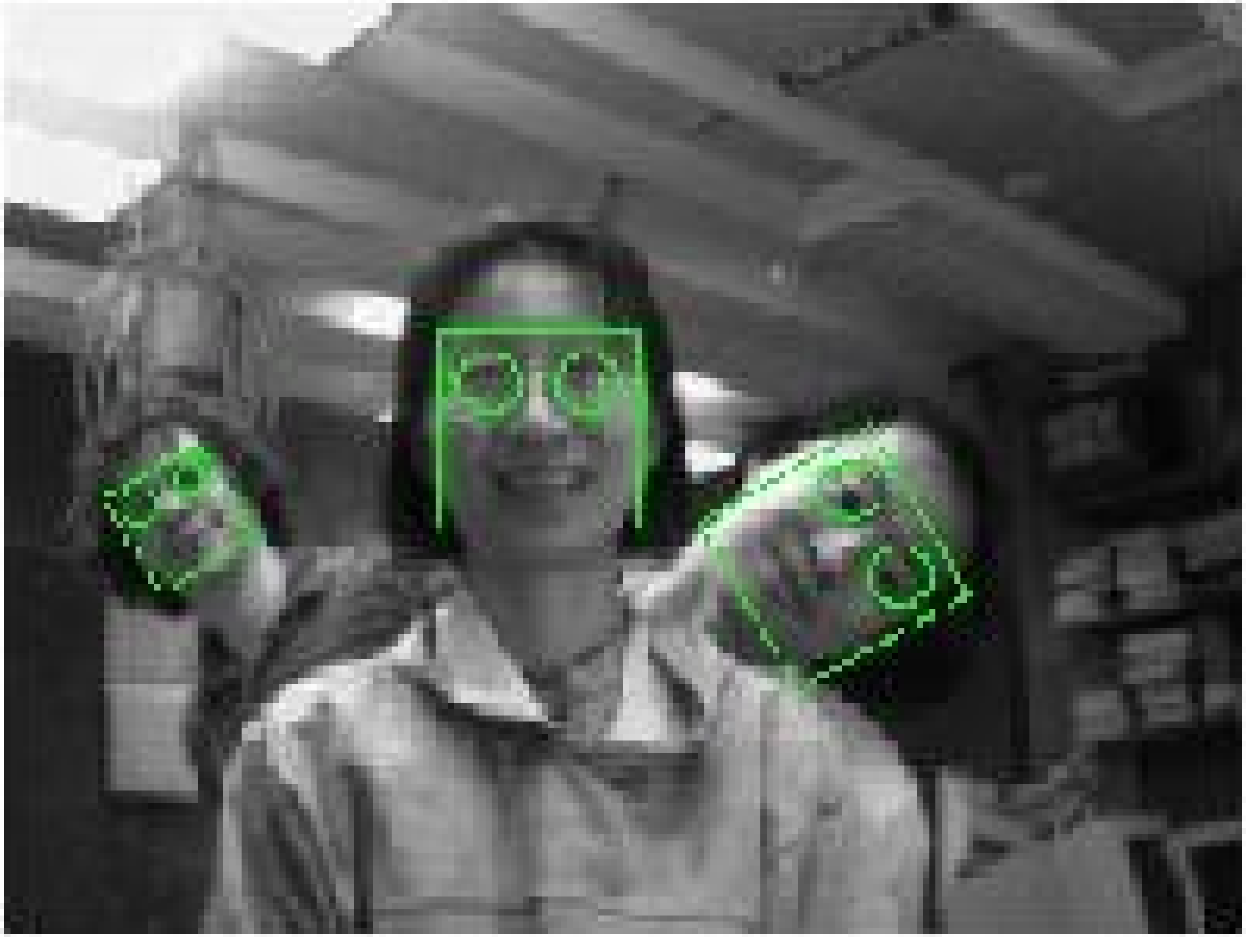
- Representing local properties of the image
  - For three reasons
    - Sharp changes are important in practice -- find “edges”
    - We wish to establish correspondence between points in different images, so we need to describe the neighborhood of the points
    - Representing texture by giving some statistics of the different kinds of small patch present in the texture.
      - Tigers have lots of bars, few spots
      - Leopards are the other way

Course Overview
Part III: Vision in Multiple Images

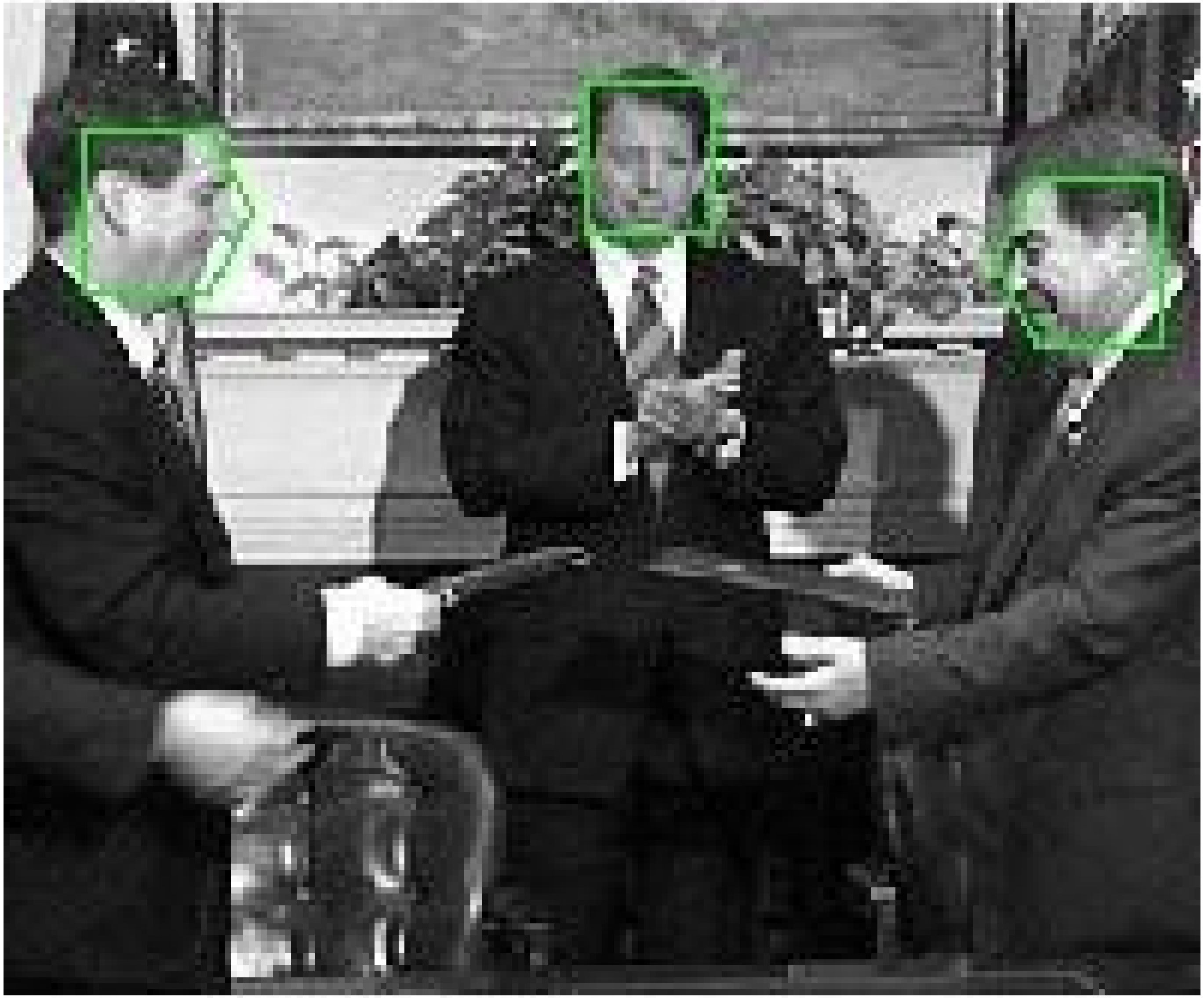
- The geometry of multiple views
  - Where could it appear in camera 2 (3, etc.) given it was here in 1?
  - Stereopsis
  - What we know about the world from having 2 eyes
- Structure from motion
  - What we know about the world from having many eyes
    - or, more commonly, our eyes moving.
- Correspondence
  - Which points in the images are projections of the same 3D point?
  - Solve for positions of all cameras and points.

Course Overview
Part IV: High Level Vision

- Model based vision
    - find the position and orientation of known objects
- Using classifiers and probability to recognize objects
  - Templates and classifiers
    - how to find objects that look the same from view to view with a classifier
  - Relations
    - break up objects into big, simple parts, find the parts with a classifier, and then reason about the relationships between the parts to find the object



http://www.ri.cmu.edu/projects/project_271.html



http://www.ri.cmu.edu/projects/project_320.html

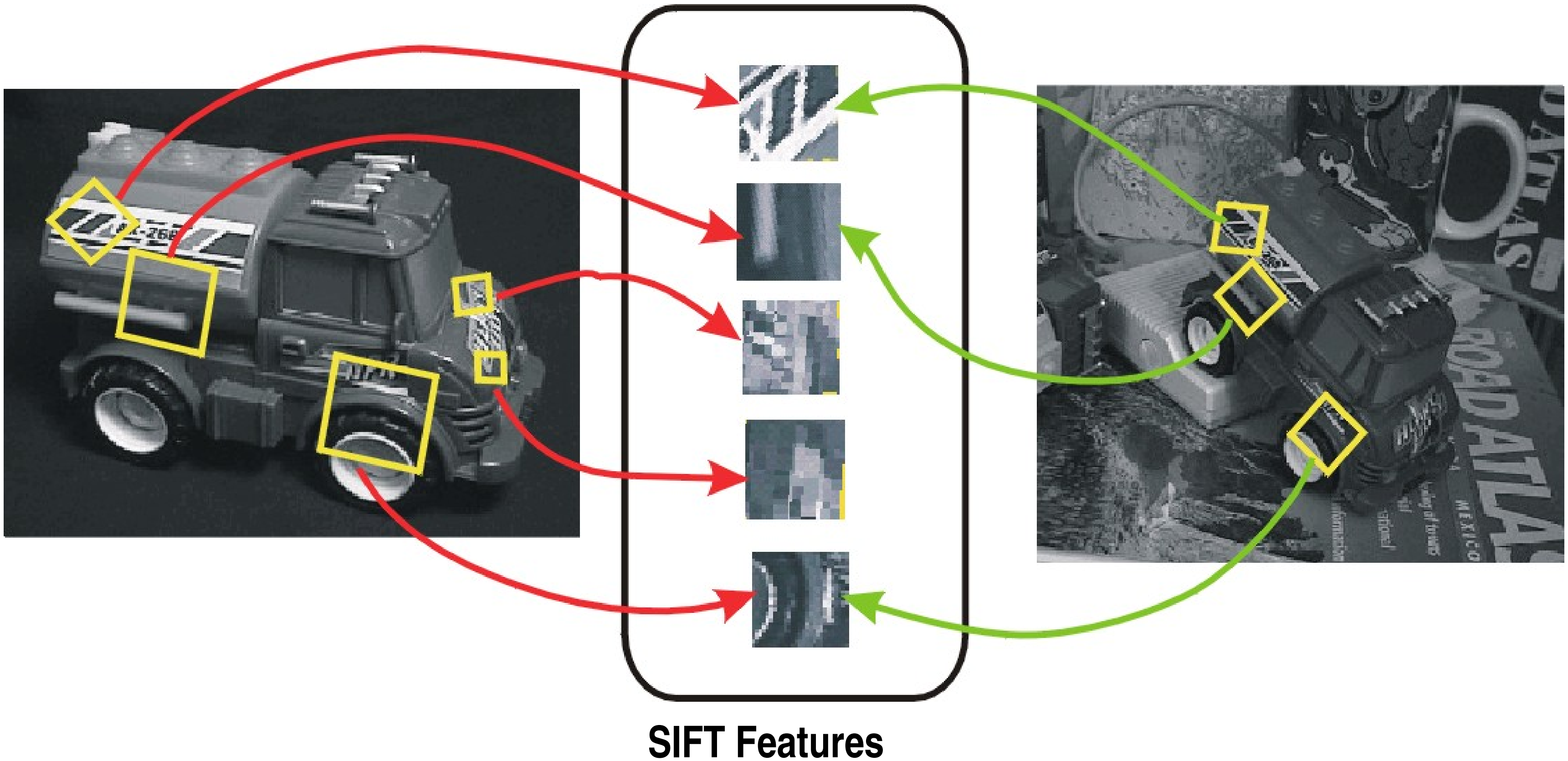
Course Overview
Object and Scene Recognition (my research)

- **Definition:** Identify objects or scenes and determine their pose and model parameters

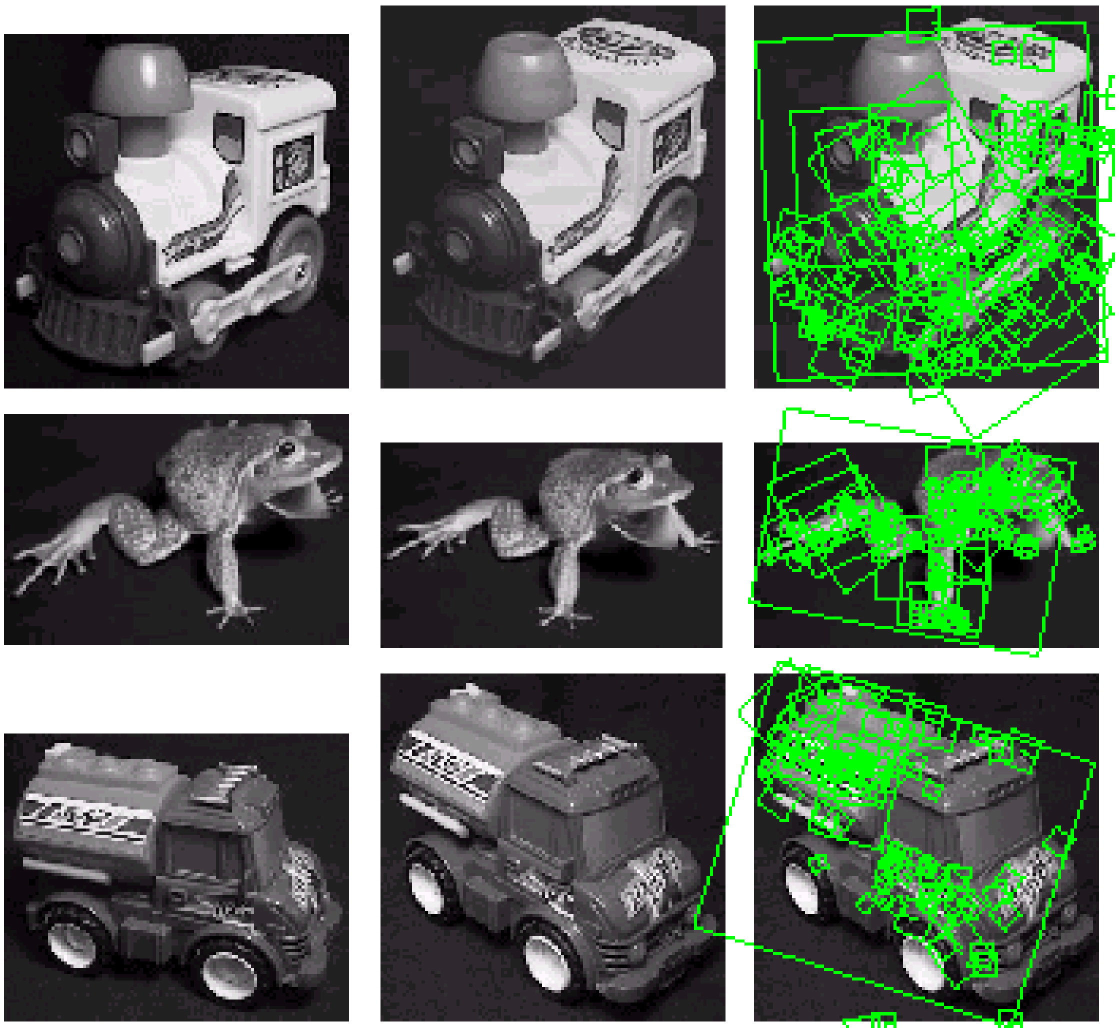
- **Applications**
  - Industrial automation and inspection
  - Mobile robots, toys, user interfaces
  - Location recognition
  - Digital camera panoramas
  - 3D scene modeling

Invariant Local Features

- Image content is transformed into local feature coordinates that are invariant to translation, rotation, scale, and other imaging parameters



Examples of view interpolation



Recognition using View Interpolation