Computational Perception

- Vision: To know what is where by looking -*Aristotle*
- Perception: Entraining (building and maintaining) models of our world from sense data. Events, actions and intentions are also included.
- Active Perception: Controlling the use of various sensors for the purpose of perception.
- Common computational problems for most sensors. Eg. Hearing, touch, sonar, laser rangefinder. (Latter two are "active sensors.")

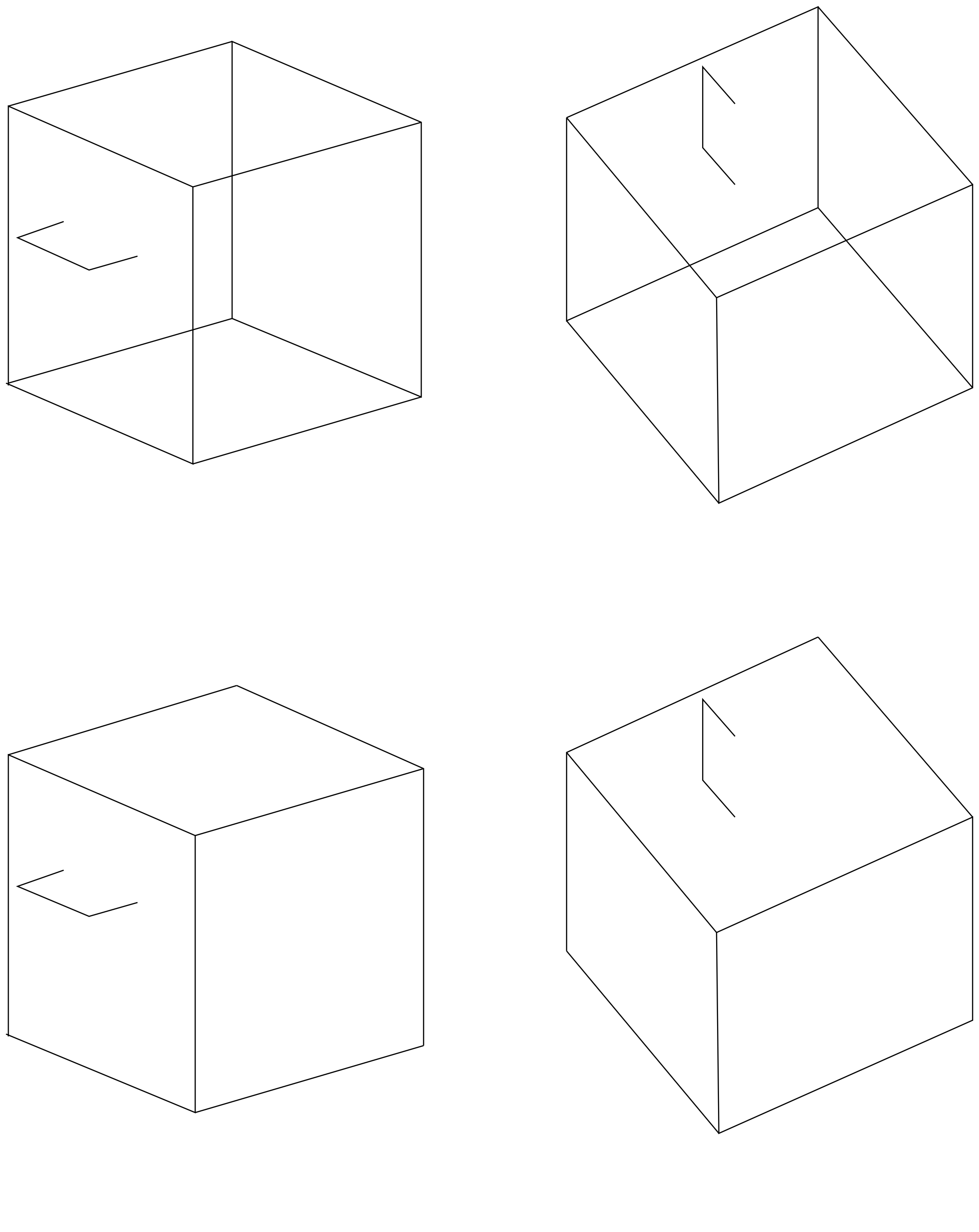
Computational Perception Problem

What's the *nature* of the computational perception problem?
We need to specify:

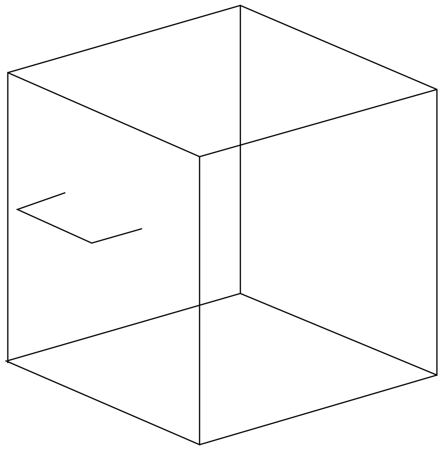
- Mathematical formulation of the problem.
- Computational solution.

Illusions help to illustrate the nature of the problem.

Necker Cube with Handle



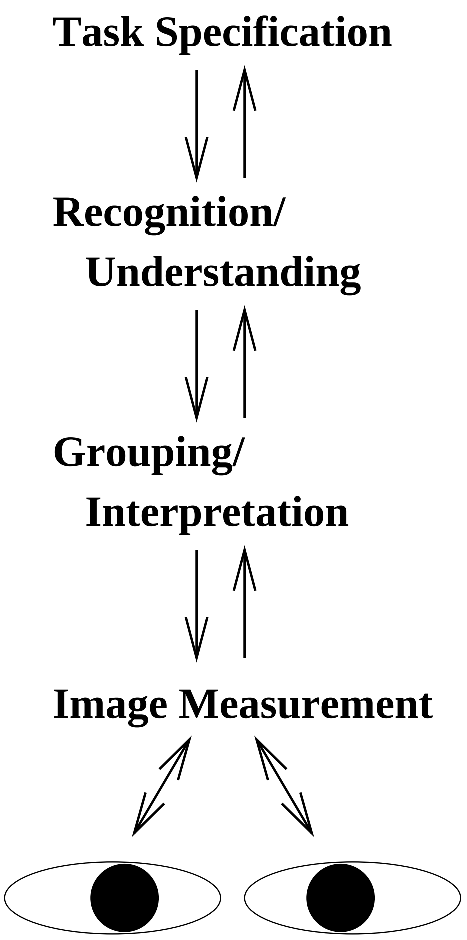
Necker Cube with Handle

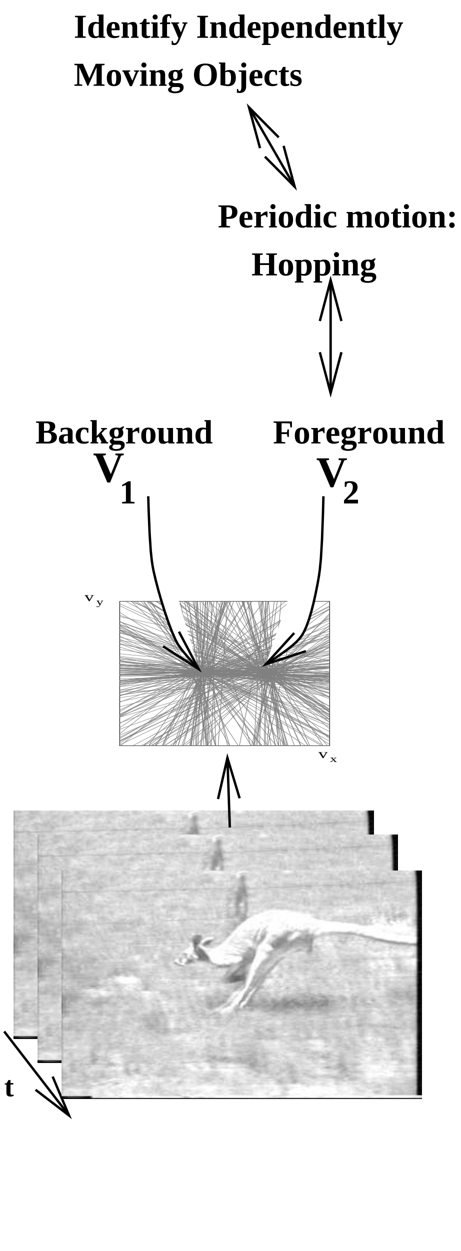


Perceptual Inference

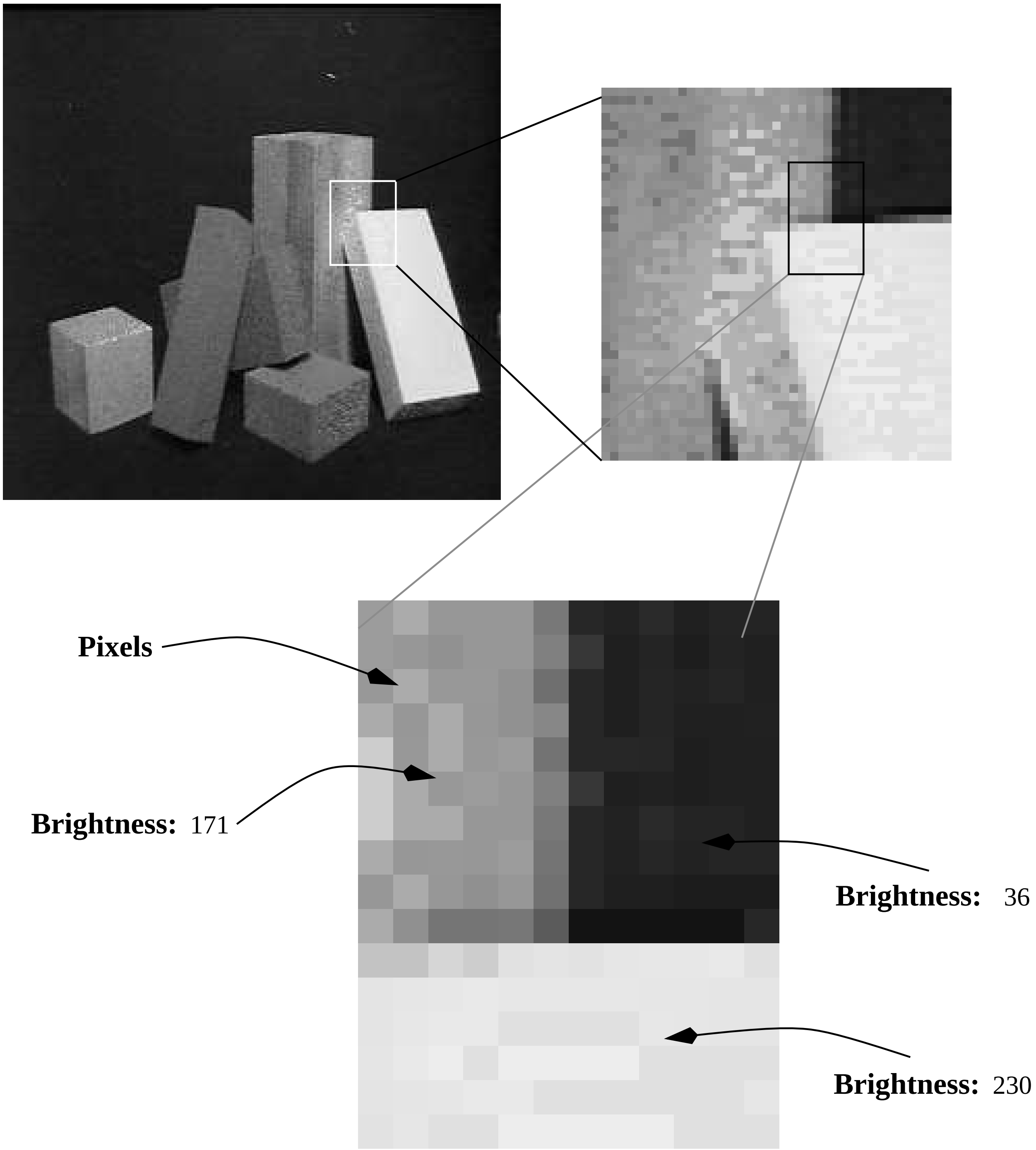
- Perception involves inference.
- Remember Aristotle
  – Vision: To ***know*** what is where by looking.
- Biological Perception
  – To infer what is where by sensing.
- Machine Perception
  – To come to a misguided belief of what is where by sensing. =:O

Levels of Vision



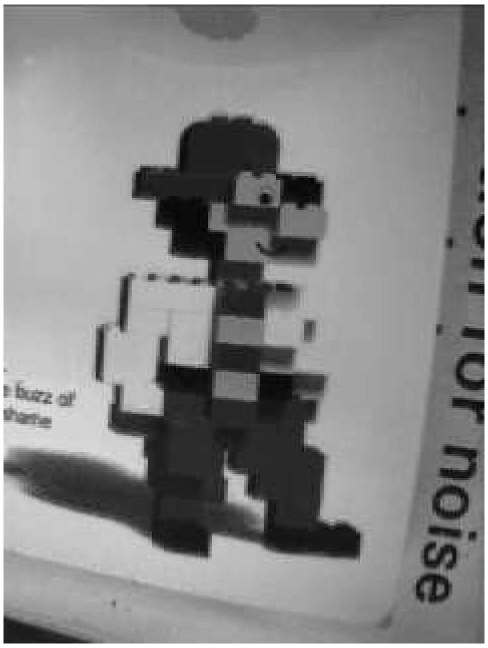


Digital Images

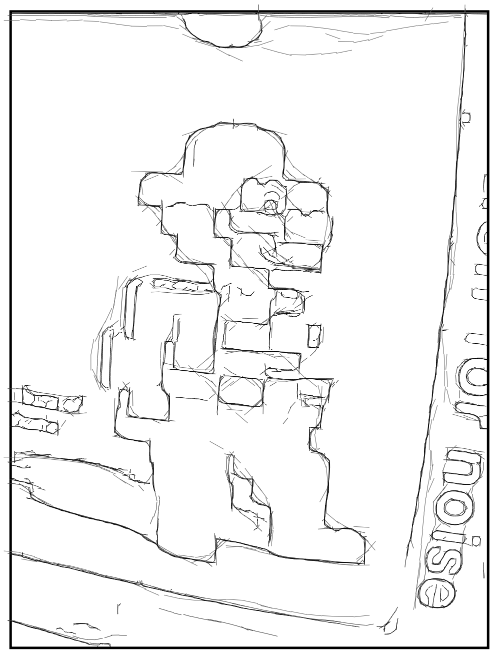


Pixel Brightness Stored in 1 Byte

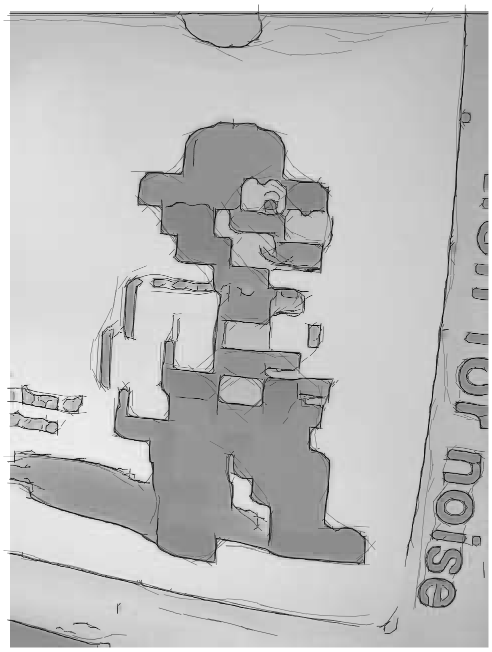
Image Edges



Microserf Image



Multi-scale Edgels



Overlay of edgels

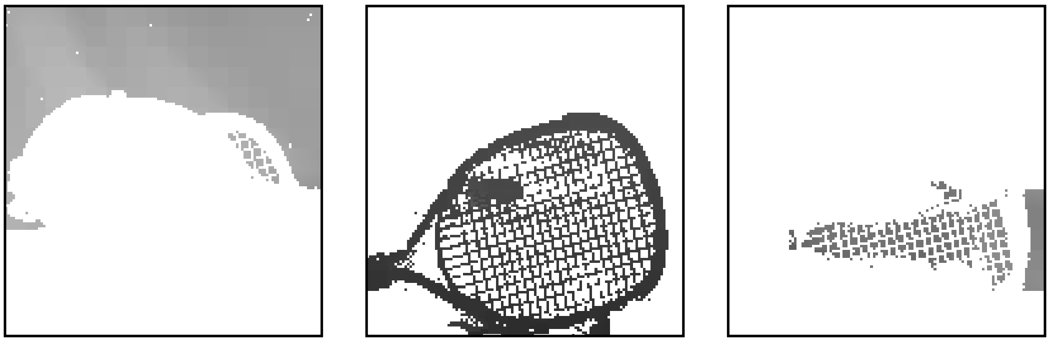
Layered Image Models

- A natural representation for images which involve overwriting (eg. occlusion or overlays).
- The general task is to identify and separate individual layers given an image (or sequence).

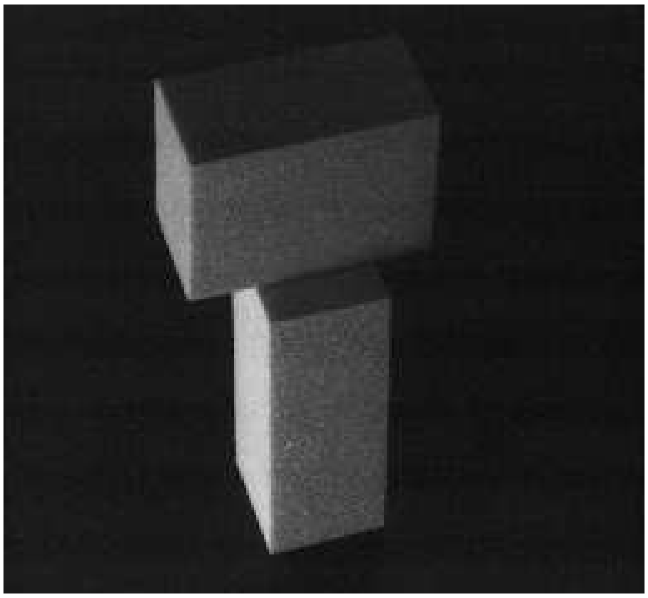
Intensity Image

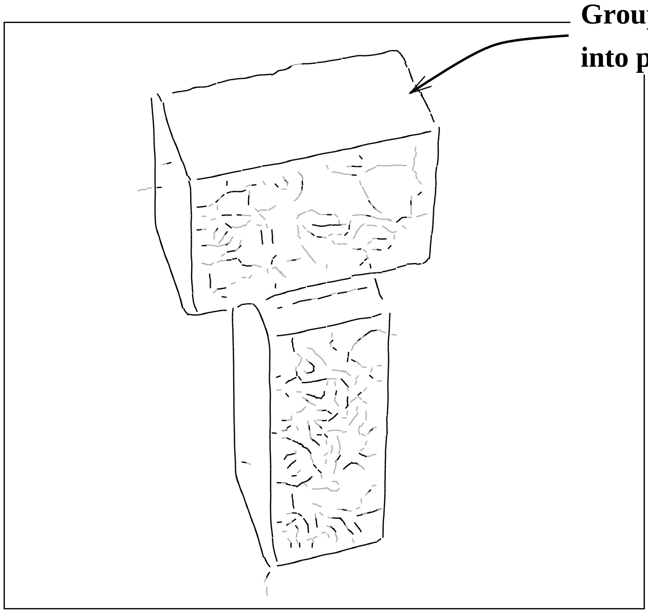
Depth Image

Example Depth Layers



Identifying Parts

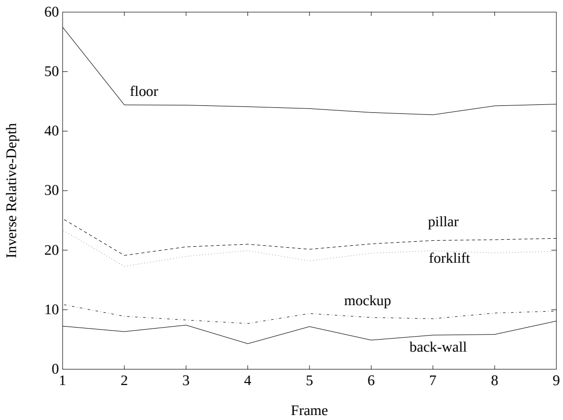




Group long edges into part.

Image Motion and Structure

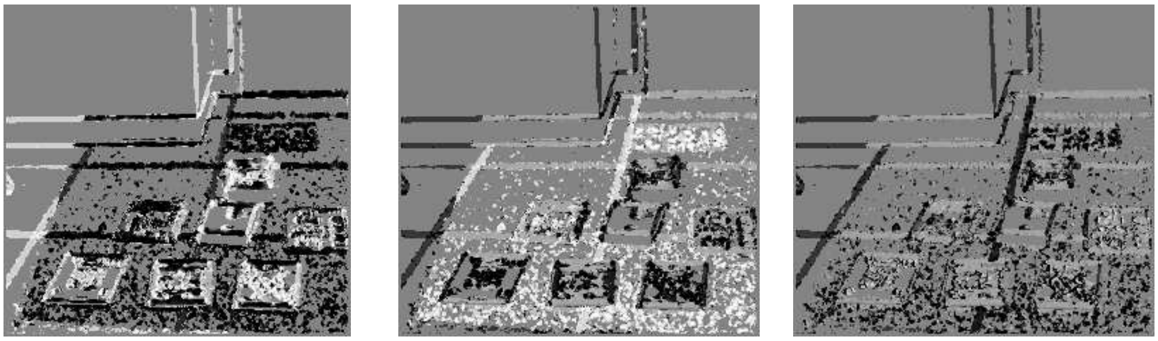
Frame from ‘forklift’ sequence



Recovered range.

Stereo Images

A calibrated stereo image pair.

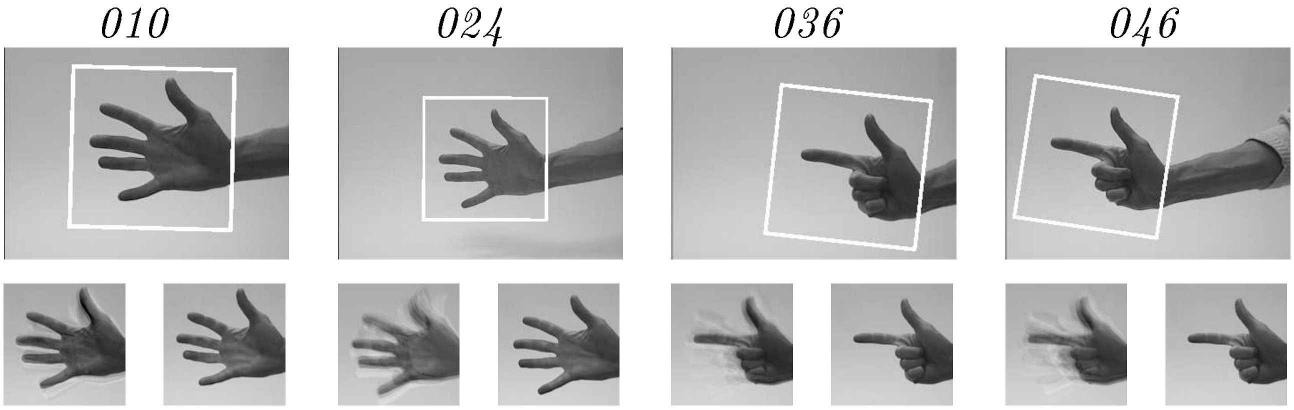


Ownership for outliers, floor, and consistent.

Gesture Recognition

Sample Hand Gestures:

Frames from a test sequence showing tracking results:



The small images above show the recovered model and the motion-stabilized images.

Motion Understanding

- **The Problem:** “What happened in this movie?”

- **The Approach:** Physics-based analysis of simplified scene model.
- **Example:**

  – Can is a ‘passive object’ (resting on table).
  – Hand is an ‘active object’ (moving above table).
  – Hand lifts can off table (by attaching to it).

Related Areas

- Statistical Estimation Theory
- Probabilistic Inference
- Optimization Methods
- Image Processing
- Physics of Scenes and Graphics
- Artificial Intelligence
- Psychophysics
- Machine Learning
- Pattern Recognition
- Physiology

Machine Vision Applications

1. Industrial Vision Systems
   - Part recognition
   - Quality control
   - Closed loop arm positioning
   - Surveillance/Security
   - Reading/filing documents
   - Driver/pilot's aid
2. Mobile Robots
   - Landmarks and navigation
   - Obstacle detection
   - Terrain mapping
   - Object search/recognition
   - Monitoring, anomaly detection
3. Perceptual User Interfaces (PUIs)
   - User recognition
   - Gesture recognition
   - Gaze direction
   - American sign language
   - Lip reading
4. Image and Video Databases
   - Compression
   - Classification and retrieval
   - Video annotation
   - Meeting capture
5. Graphics
   - Embedding graphics objects into video
   - Controlling graphics objects from video
   - Learning graphics models from video