CMSC 426: Image Processing (Computer Vision)

David Jacobs

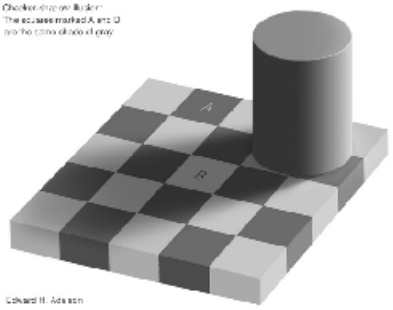
Vision

- ``to know what is where, by looking.'' (Marr).
- Where
- What

Why is Vision Interesting?

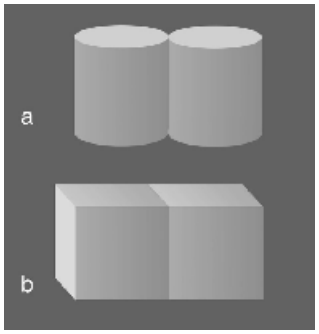
- Psychology
  - ~ 50% of cerebral cortex is for vision.
  - Vision is how we experience the world.
- Engineering
  - Want machines to interact with world.
  - Digital images are everywhere.

Vision is inferential: Light



(http://www-bcs.mit.edu/people/adelson/checkershadow_illusion.html)

Vision is Inferential

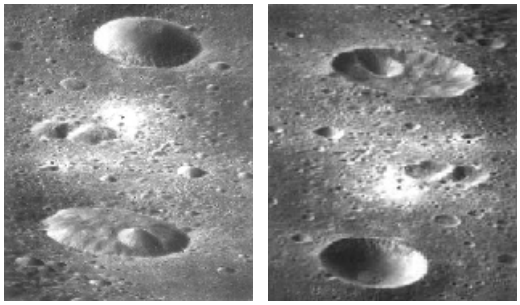


Vision is Inferential: Geometry

movie

Vision is Inferential: Prior Knowledge

Vision is Inferential: Prior Knowledge



Computer Vision

- Inference → Computation
- Building machines that see
- Modeling biological perception

A Quick Tour of Computer Vision

Boundary Detection: Local cues

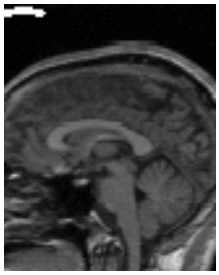
Boundary Detection: Local cues

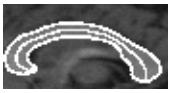
Boundary Detection

http://www.robots.ox.ac.uk/~vdg/dynamics.html

(Sharon, Balun, Brandt, Basri)

Boundary Detection



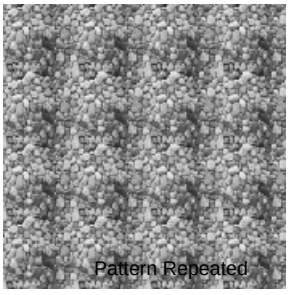


Finding the Corpus Callosum

(G. Hamarneh, T. McInerney, D. Terzopoulos)

Texture

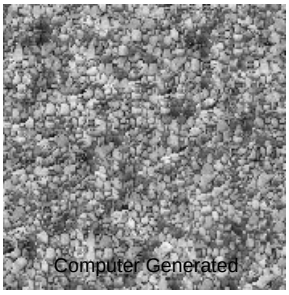
Photo



Pattern Repeated

Texture

Photo



Computer Generated

Tracking

(Comaniciu and Meer)

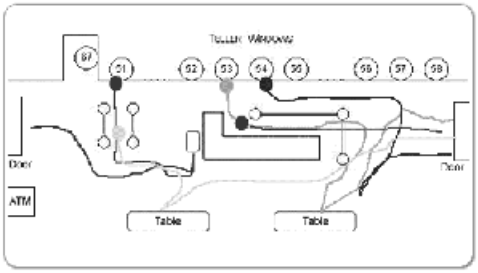
Tracking

(www.brickstream.com)

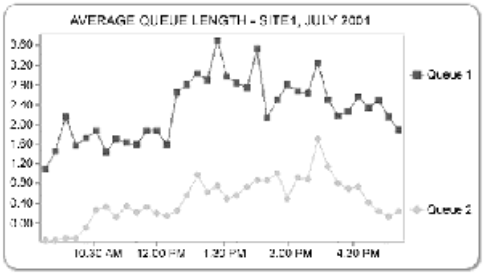
Tracking

Tracking

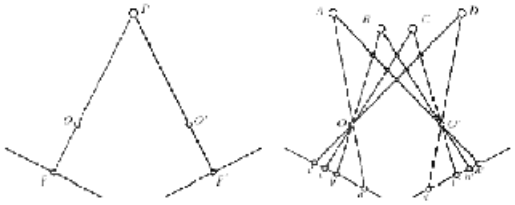
Tracking



Tracking

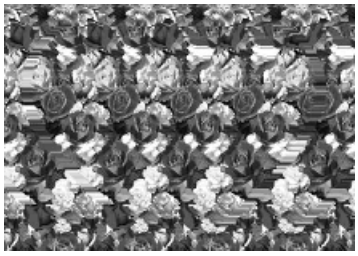


Stereo



http://www.ai.mit.edu/courses/6.801/lect/lect01_darrell.pdf

Stereo



http://www.magiceye.com/

Stereo

http://www.magiceye.com/

Motion

http://www.ai.mit.edu/courses/6.801/lect/lect01_darrell.pdf

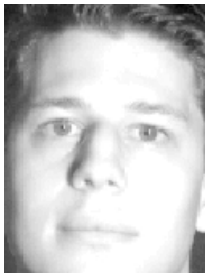
Motion - Application

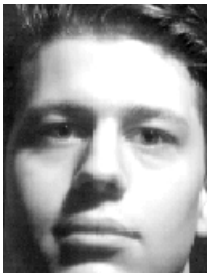
(www.realviz.com)

Pose Determination

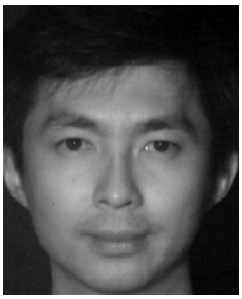
Visually guided surgery

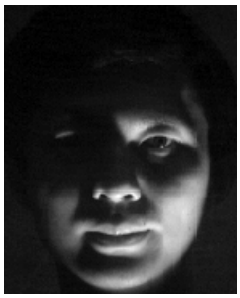
Recognition - Shading



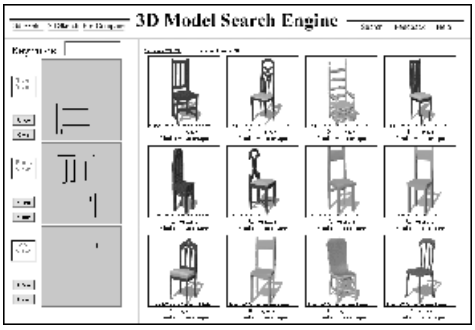


Lighting affects appearance





Classification



(Funkhauser, Min, Kazhdan, Chen, Halderman, Dobkin, Jacobs)

Vision depends on:

- Geometry
- Physics
- The nature of objects in the world
  (This is the hardest part).

Approaches to Vision

Modeling + Algorithms

- Build a simple model of the world
  (eg., flat, uniform intensity).
- Find provably good algorithms.
- Experiment on real world.
- Update model.

Problem: Too often models are simplistic or intractable.

Bayesian inference

- Bayes law: P(A|B) = P(B|A)*P(A)/P(B).
- P(world|image) =
  P(image|world)*P(world)/P(image)
- P(image|world) is computer graphics
  - Geometry of projection.
  - Physics of light and reflection.
- P(world) means modeling objects in world.
  Leads to statistical/learning approaches.

Problem: Too often probabilities can't be known and are invented.

Engineering

- Focus on definite tasks with clear requirements.
- Try ideas based on theory and get experience about what works.
- Try to build reusable modules.

Problem: Solutions that work under specific conditions may not generalize.

Marr

- Theory of Computation
- Representations and algorithms
- Implementations.

- Primal Sketch
- 2½D Sketch
- 3D Representations

Problem: Are things really so modular?

The State of Computer Vision

- Science
  - Study of intelligence seems to be hard.
  - Some interesting fundamental theory about specific problems.
  - Limited insight into how these interact.

The State of Computer Vision

- Technology
  - Interesting applications: inspection, graphics, security, internet….
  - Some successful companies. Largest ~100-200 million in revenues. Many in-house applications.
  - Future: growth in digital images exciting.

Related Fields

- Graphics. "Vision is inverse graphics".
- Visual perception.
- Neuroscience.
- AI
- Learning
- Math: eg., geometry, stochastic processes.
- Optimization.

Contact Info

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Tools Needed for Course

- Math
  - Calculus
  - Linear Algebra (can be picked up).
- Computer Science
  - Algorithms
  - Programming, we'll use Matlab.
- Signal Processing (we'll teach a little).

Rough Syllabus

Course Organization

- Reading assignments in Forsyth & Ponce, plus some extras.
- ~6-8 Problem sets
  - Programming and paper and pencil
- Two quizzes, Final Exam.
- Grading: Problem sets 30%, quizzes: first quiz 10%; second quiz 20%; final 40%.
- Web page: www.cs.umd.edu/~djacobs/CMSC426/CMSC426.htm