Optical Flow

Problem:
Determine how objects (and/or the camera itself) move in the 3D world

Key Idea(s):
Images acquired as a (continuous) function of time provide additional constraint. Formulate motion analysis as finding (dense) point correspondences over time.
Optical Flow and 2D Motion

Optical flow is the apparent motion of brightness patterns in the image.

Applications
- image and video stabilization in digital cameras, camcorders
- motion-compensated video compression schemes such as MPEG
- image registration for medical imaging, remote sensing
- action recognition
- motion segmentation
**Optical Flow** and 2D Motion

**Motion** is geometric

**Optical flow** is radiometric

Usually we assume that optical flow and 2-D motion coincide ... but this is not always the case!
Optical Flow and 2D Motion

Optical flow but no motion . . .
Optical Flow and 2D Motion

**Optical flow** but **no motion** . . .

. . . moving light source(s), lights going on/off, inter-reflection, shadows
Optical Flow and 2D Motion

Optical flow but no motion . . .

. . . moving light source(s), lights going on/off, inter-reflection, shadows

Motion but no optical flow . . .
Optical Flow and 2D Motion

Optical flow but no motion . . .
. . . moving light source(s), lights going on/off, inter-reflection, shadows

Motion but no optical flow . . .
. . . spinning sphere.
Optical Flow and 2D Motion

Here’s a video example of a very skilled Japanese contact juggler working with a clear acrylic ball

Source: http://youtu.be/CtztrcGkCBw?t=1m20s

A key element to the illusion is motion without corresponding optical flow
Example 1: Rotating Ellipse
Example 1: Three “Percepts”

1. **Veridical:**
   - a 2-D rigid, flat, rotating ellipse

2. **Amoeboid:**
   - a 2-D, non-rigid “gelatinous” smoothly deforming shape

3. **Stereokinetic:**
   - a circular, rigid disk rolling in 3-D
Example 1: Rotating Ellipse

A narrow ellipse oscillating rigidly about its center appears **rigid**
Example 1: Rotating Ellipse

However, a fat ellipse undergoing the same motion appears nonrigid

Video credits: Yair Weiss
The apparent nonrigidity of a fat ellipse is not really a "visual illusion". A rotating ellipse or a nonrigid pulsating ellipse can cause the exact same stimulation on our retinas. In this sequence the ellipse contour is always doing the same thing, only the markers' motion changes.

**Example 1: Rotating Ellipse**

**Video credits**: Yair Weiss
Example 1: Rotating Ellipse

The ellipse's motion can be influenced by features not physically connected to the ellipse. In this sequence the ellipse is always doing the same thing, only the dots' motion changes.
Bees have very limited stereo perception. How do they fly safely through narrow passages?
Example: Flying Insects and Birds

Bees have very limited stereo perception. How do they fly safely through narrow passages?

A simple strategy would be to balance the speeds of motion of the images of the two walls. If wall A is moving faster than wall B, what should you (as a bee) do?
**Example**: Flying Insects and Birds

**Bee strategy**: Balance the optical flow experienced by the two eyes

*Figure credit*: M. Srinivasan
How do bees land safely on surfaces?

During their approach, bees continually adjust their speed to hold constant the optical flow in the vicinity of the target

— approach speed decreases as the target is approached and reduces to zero at the point of touchdown

— no need to estimate the distance to the target at any time
Example: Flying Insects and Birds

Bees approach the surface more slowly if the spiral is rotated to augment the rate of expansion, and more quickly if the spiral is rotated in the opposite direction.

Figure credit: M. Srinivasan
Example: Flying Insects and Birds

Figure credit: M. Srinivasan
In which direction is the line moving?

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)
Aperture Problem

In which direction is the line moving?

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)
Aperture Problem
Aperture Problem

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)
Aperture Problem

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)
Aperture Problem

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)