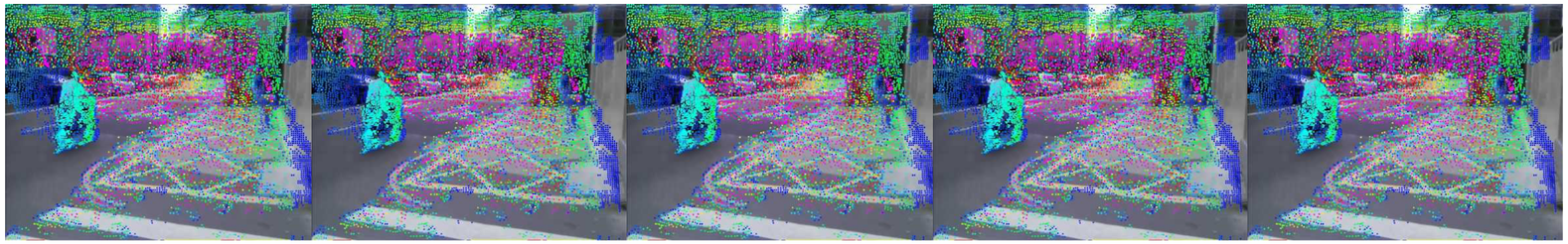
CPSC 425: Computer Vision



Lecture 16: Optical Flow

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** . . .

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

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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.

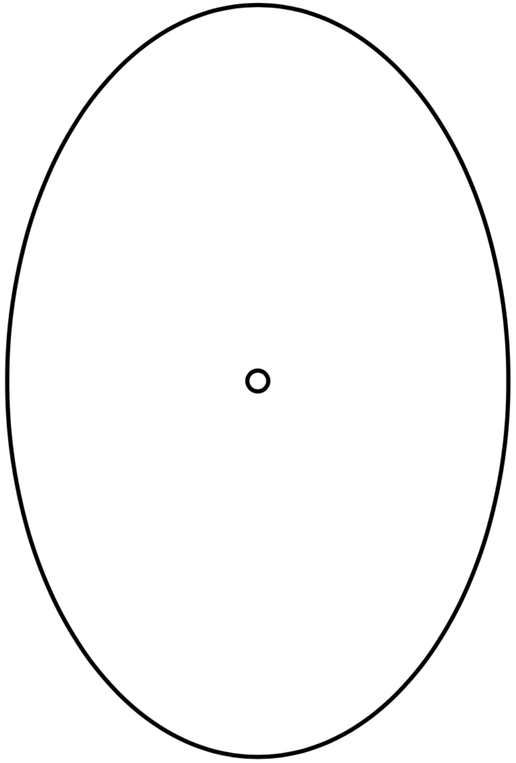
Optical Flow and 2D Motion

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**:

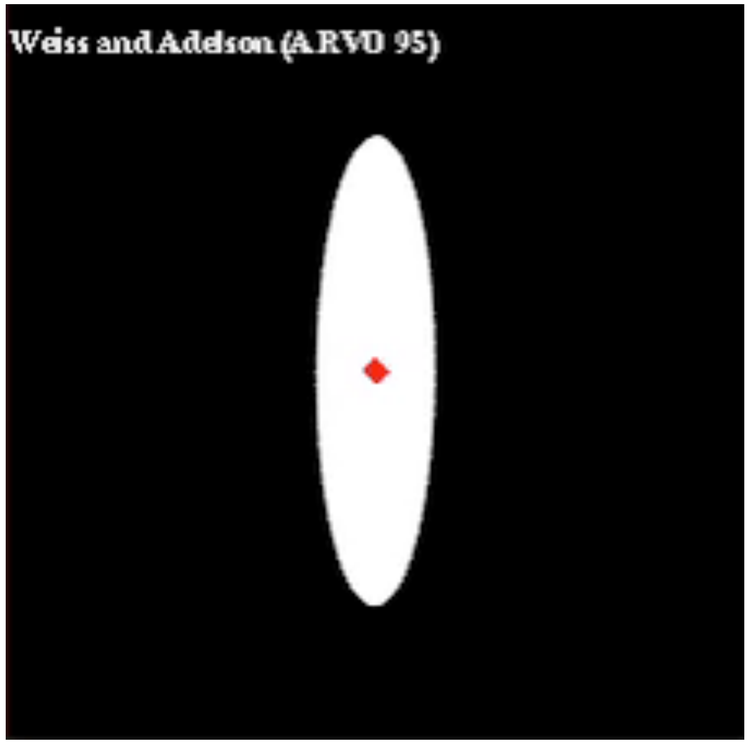
— a 2-D, non-rigid “gelatinous” smoothly deforming shape

3. **Stereokinetic**:

— a circular, rigid disk rolling in 3-D

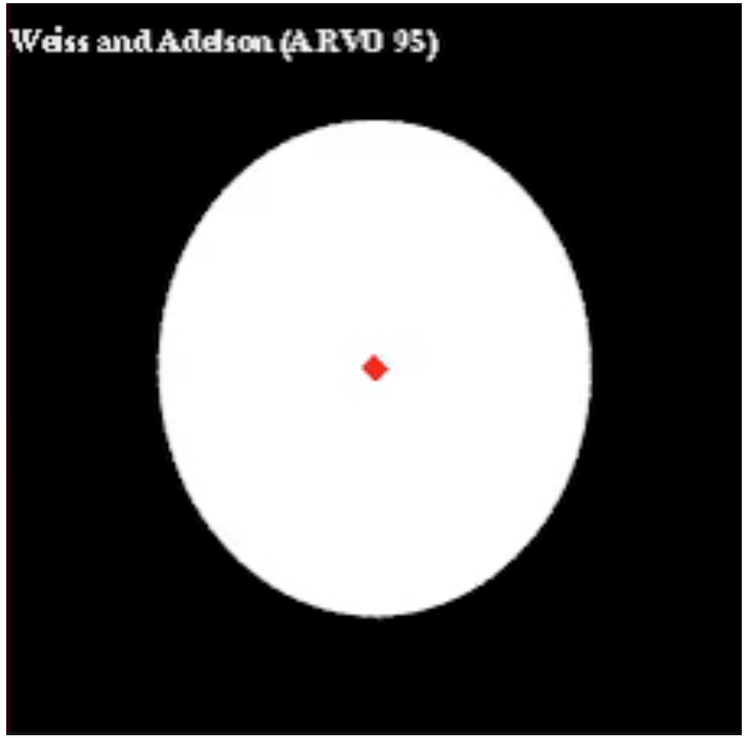
Example 1: Rotating Ellipse

A narrow ellipse oscillating rigidly about its center appears **rigid**



Example 1: Rotating Ellipse

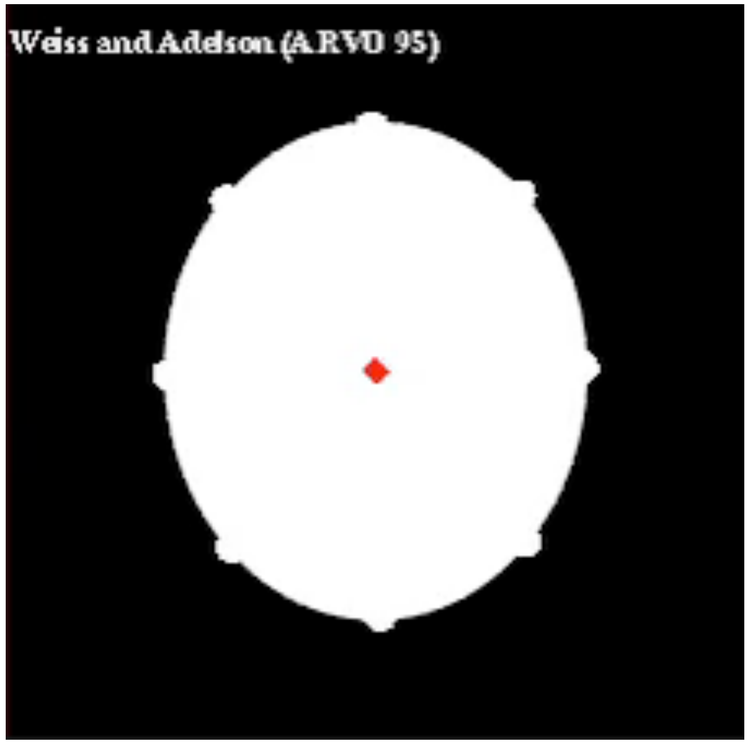
However, a fat ellipse undergoing the same motion appears **nonrigid**



Video credits: Yair Weiss

Example 1: Rotating Ellipse

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.



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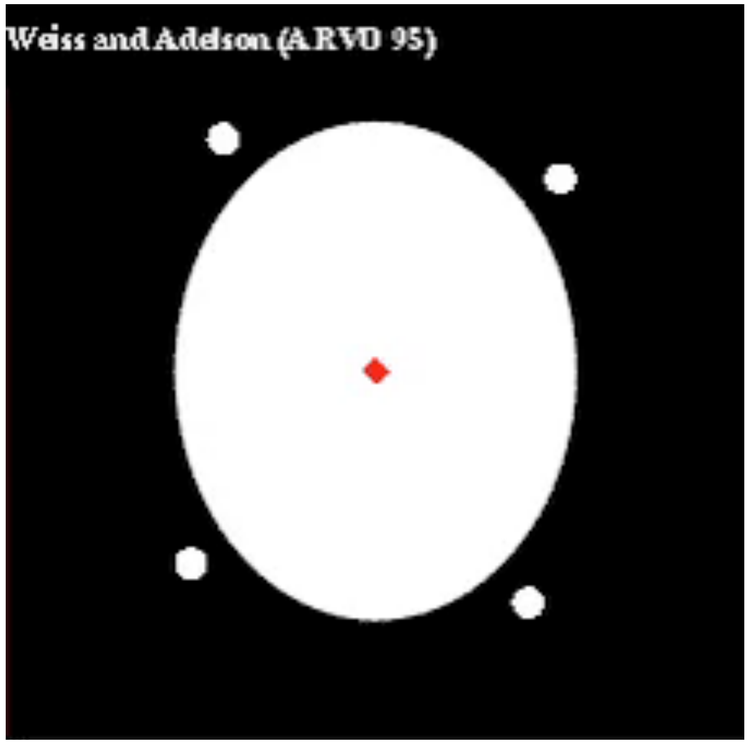
Example 1: Rotating Ellipse

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.



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Example: Flying Insects and Birds

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

Example: Flying Insects and Birds

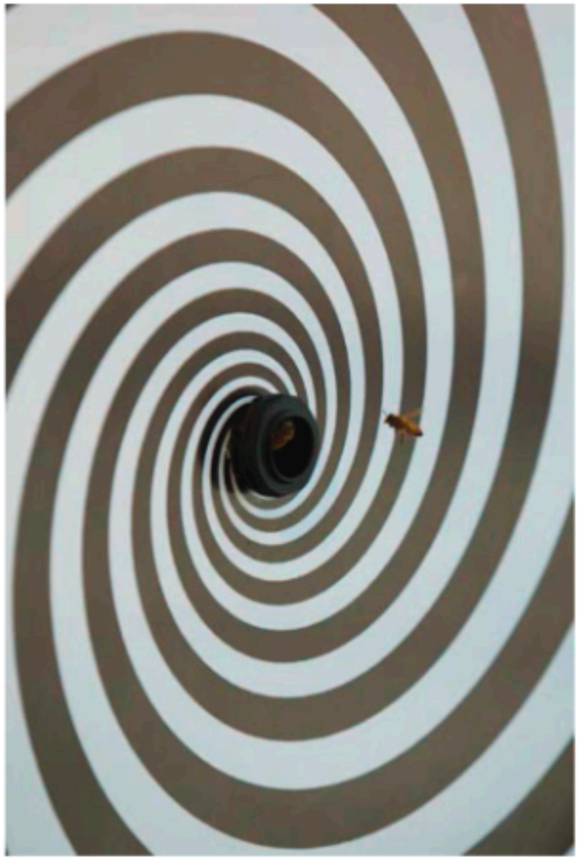
How do bees land safely on surfaces?

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

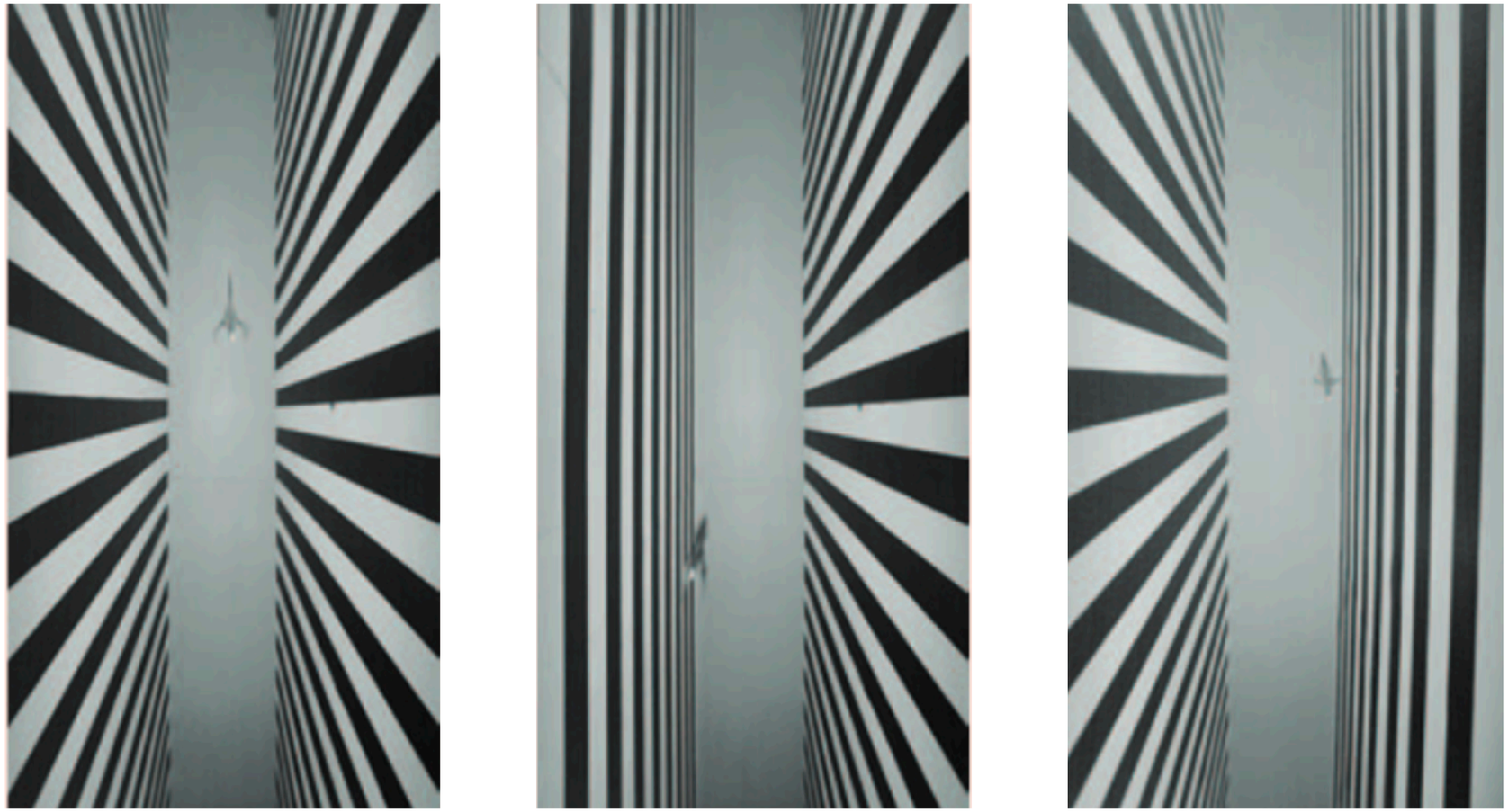
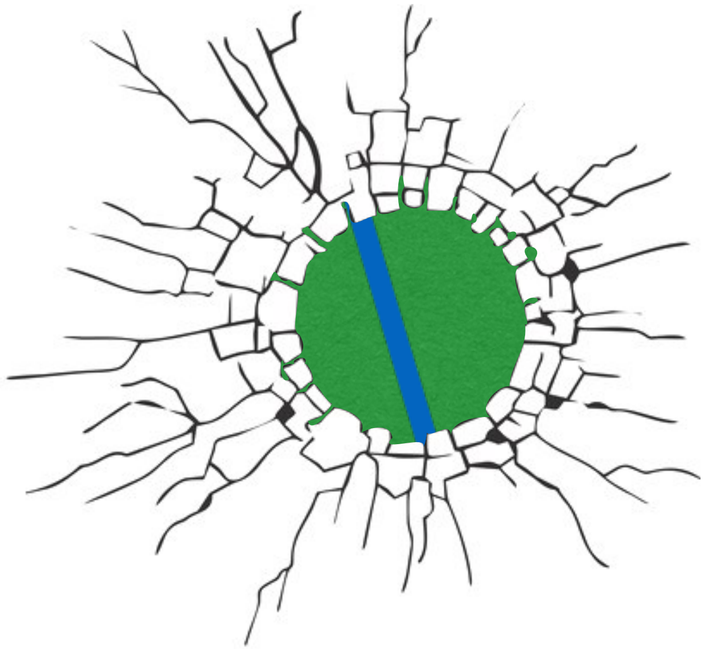


Figure credit: M. Srinivasan

Aperture Problem



In which direction is the line moving?

Image Credit: Ioannis (Yannis) Gkioulekas (CMU)

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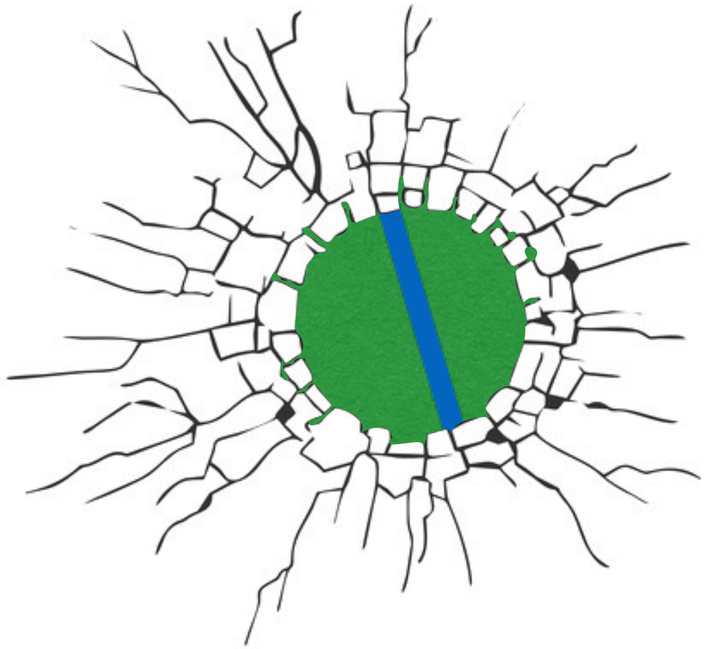

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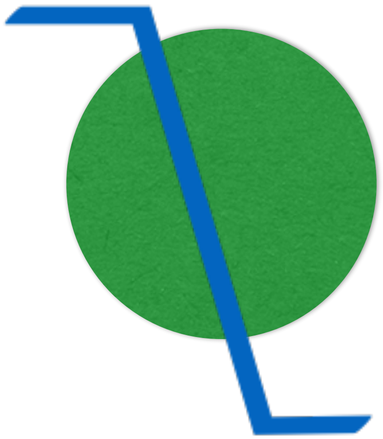

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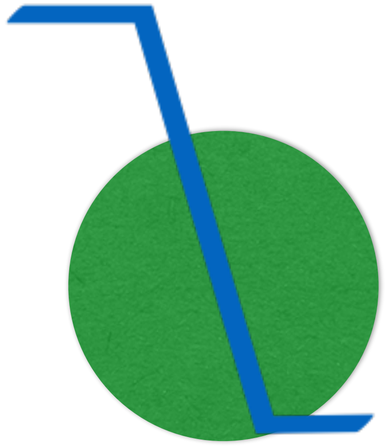

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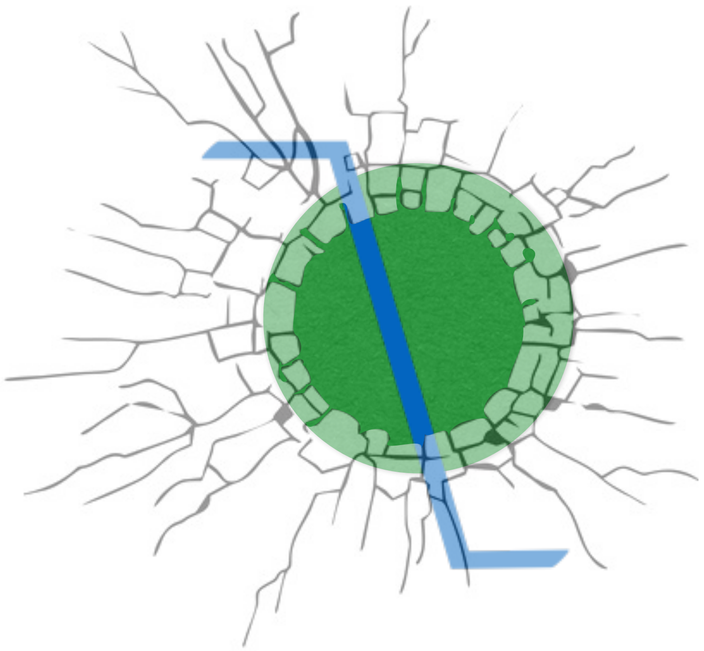

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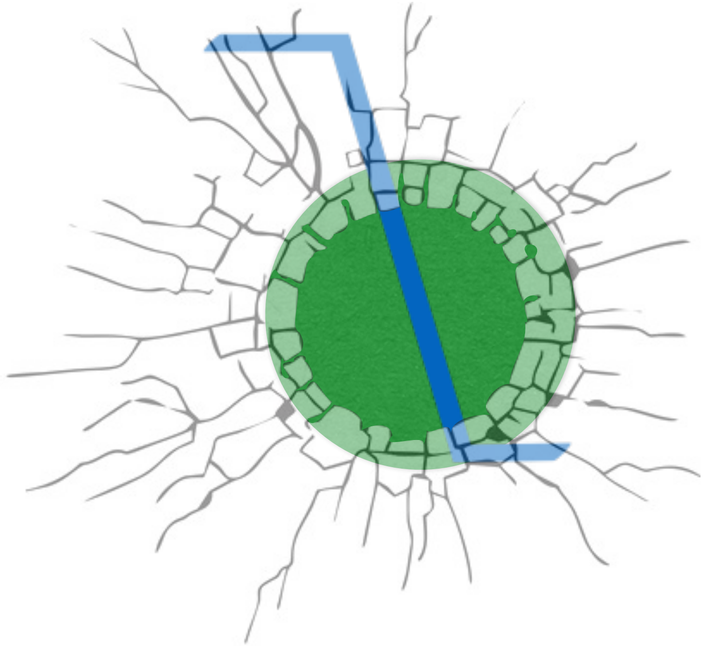

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