
6.837

Plan

- Introduction
- Overview of the semester
- Administrivia
- Iterated Function Systems (fractals)

Team

- Lecturers
  - Frédo Durand
  - Barb Cutler
- Course secretary
  - Bryt Bradley

Why Computer Graphics?

- Movies
- Games
- CAD-CAM
- Simulation
- Virtual reality
- Visualization
- Medical imaging

What you will learn in 6.837

- Fundamentals of computer graphics algorithms
- Able to implement most applications just shown
- Understand how graphics APIs and the graphics hardware work

What you will NOT learn

- Software packages
  - CAD-CAM
  - Photoshop and other painting tools
- Artistic skills
- Game design
- Graphics API
  - Although you will be exposed to OpenGL

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- Ray Tracing
  - Quiz 1
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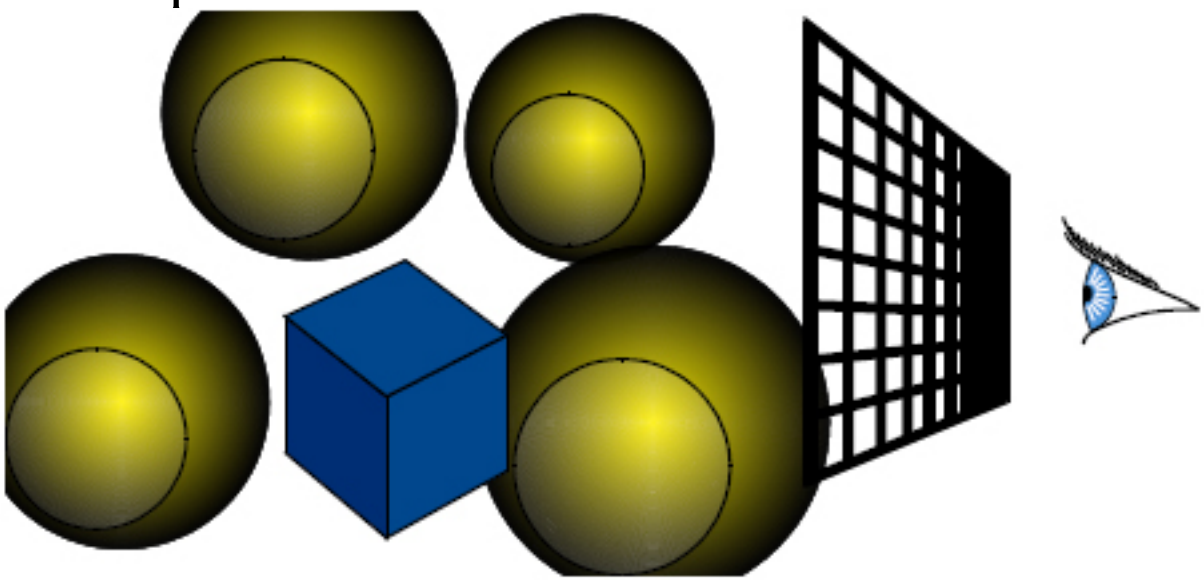
  - Choice of final project
- Rendering pipeline
  - Quiz 2
- Advanced topics

Ray Casting

- For every pixel
  construct a ray from the eye
  - For every object in the scene
    - Find intersection with the ray
    - Keep if closest



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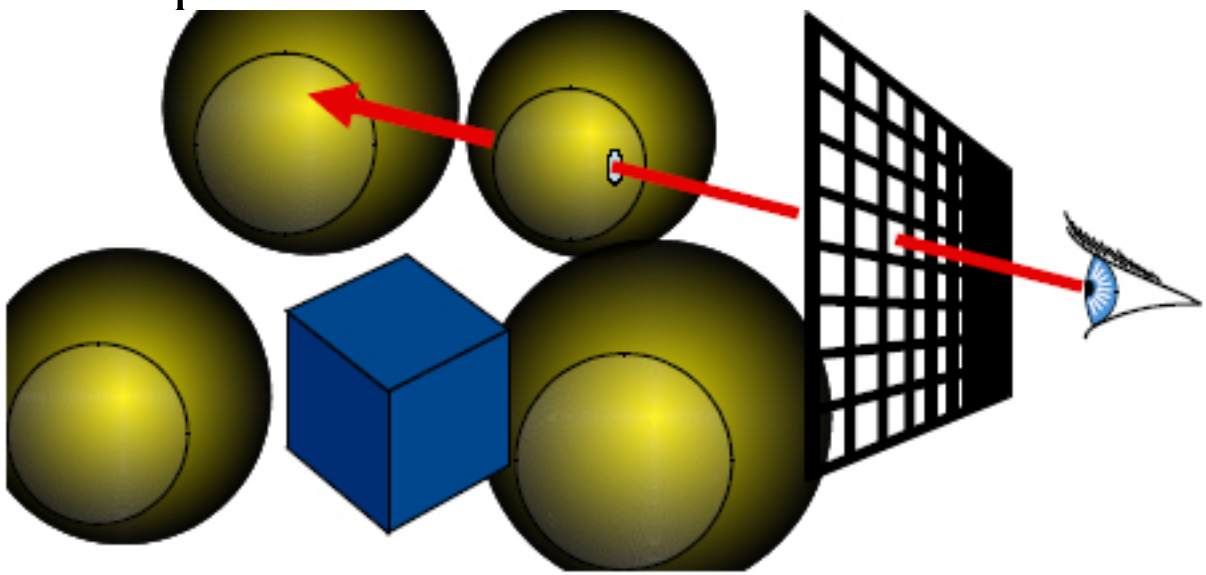
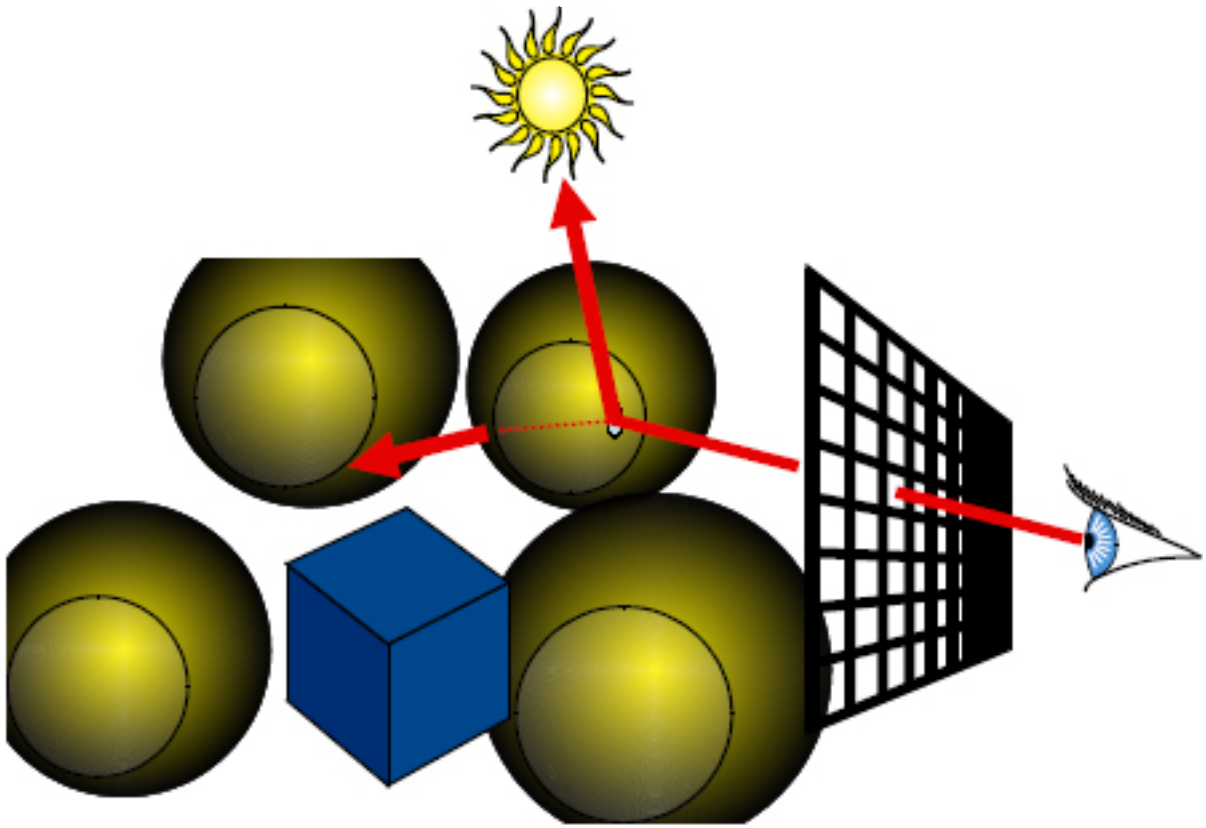


Ray Tracing

- Shade (interaction of light and material)
- Secondary rays (shadows, reflection, refraction



Ray Tracing

- Original Ray-traced image by Whitted

Image removed due to copyright considerations.

- Image computed using the Dali ray tracer by Henrik Wann Jensen
- Environment map by Paul Debevec

Image removed due to copyright considerations.

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Animation: Keyframing

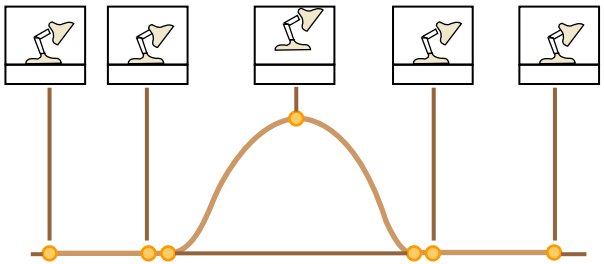
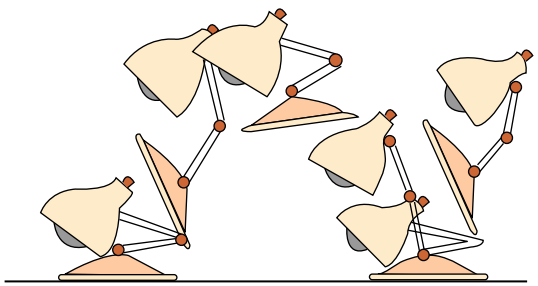


Image adapted from:
Lasseter, John. "Principles of Traditional Animation applied to 3D Computer Animation." *ACM SIGGRAPH Computer Graphics* 21, no. 4 (July 1987): 35-44.

Squash & Stretch in Luxo Jr.'s Hop



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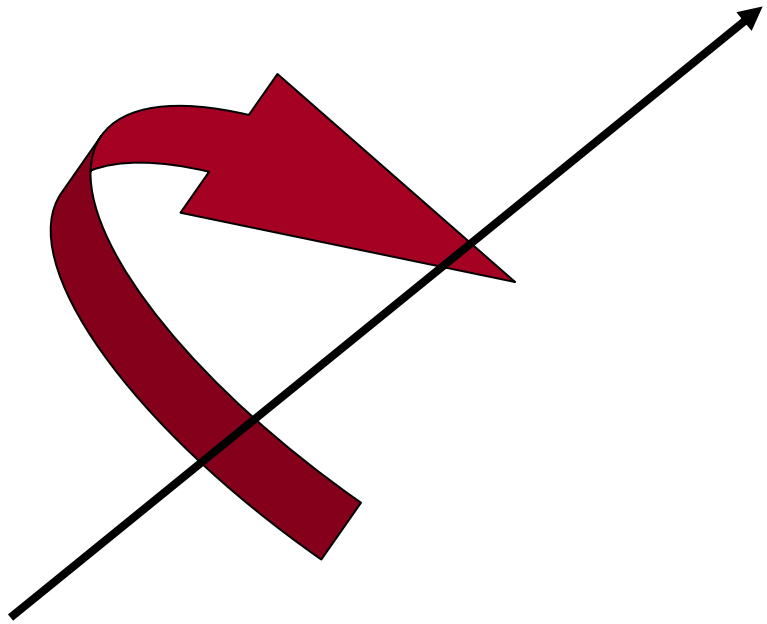

Particle system (PDE)

- Animation
  - Keyframing and interpolation
  - Simulation

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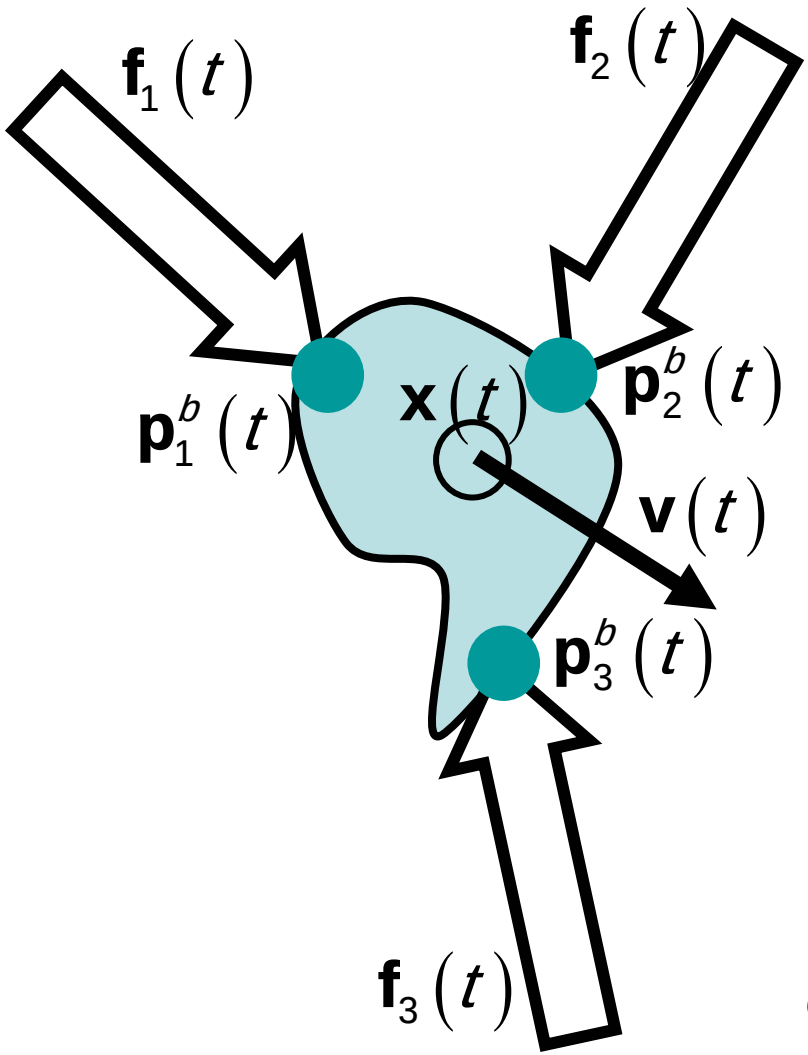
Rigid body dynamics

- Simulate all external forces and torques



Modeling

- Curved surfaces
- Subdivision surfaces

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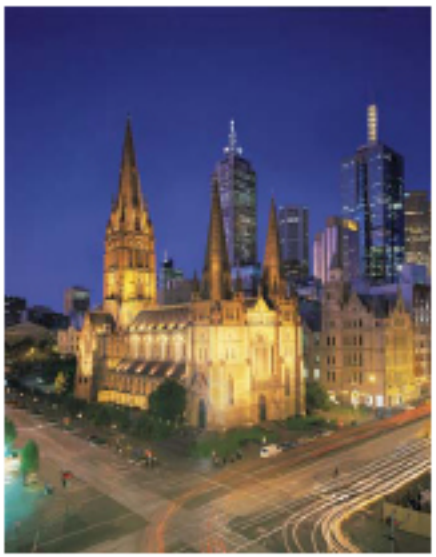
Image-based Rendering

- Use images as inputs and representation
- E.g. Image-based modeling and photo editing
  Boh, Chen, Dorsey and Durand 2001



Input image

New viewpoint

Relighting

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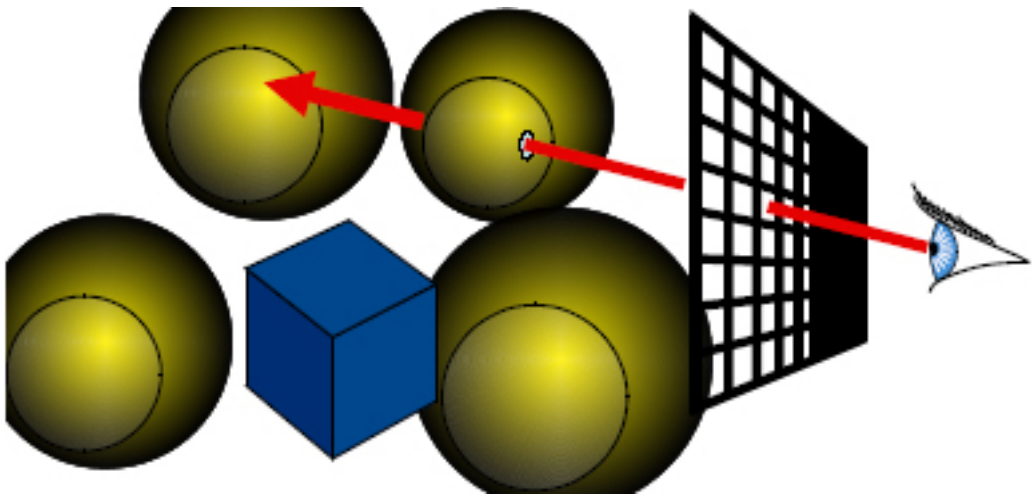
The Rendering Pipeline

Ray Casting

- For each pixel
  - For each object

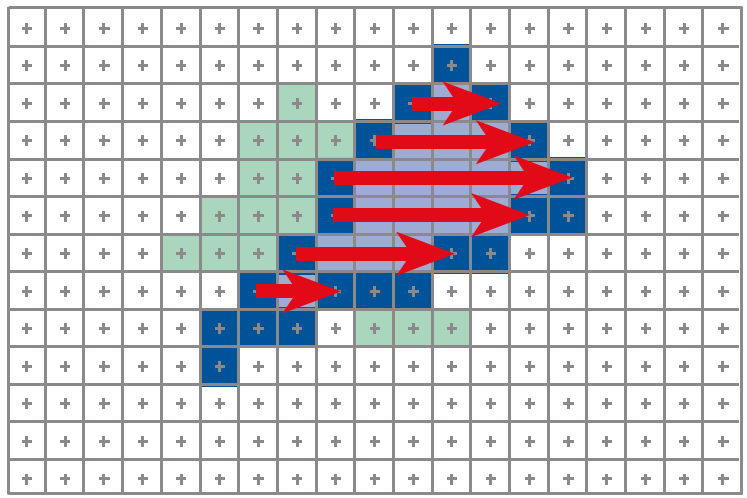
Send pixels to the scene



Rendering Pipeline

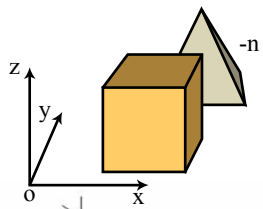
- For each triangle
  - For each projected pixel

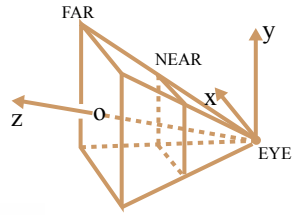
Project scene to the pixels

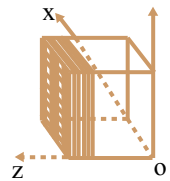


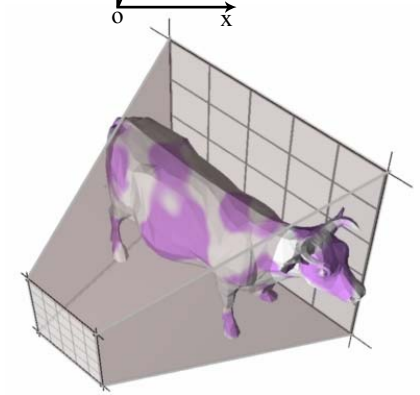
The Rendering Pipeline

- Transformations
- Clipping
- Rasterization
- Visibility

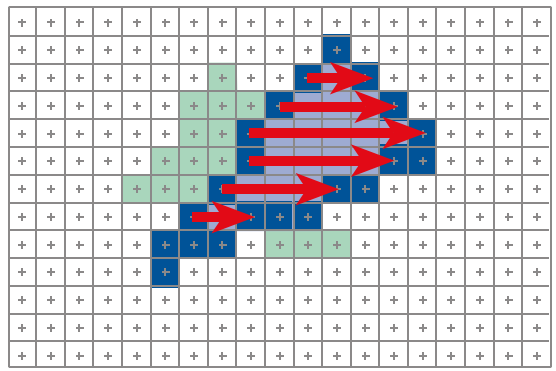


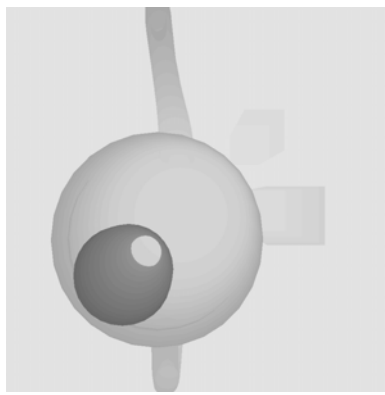






Courtesy of Leonard McMillan, Computer Science at the University of North Carolina in Chapel Hill. Used with permission





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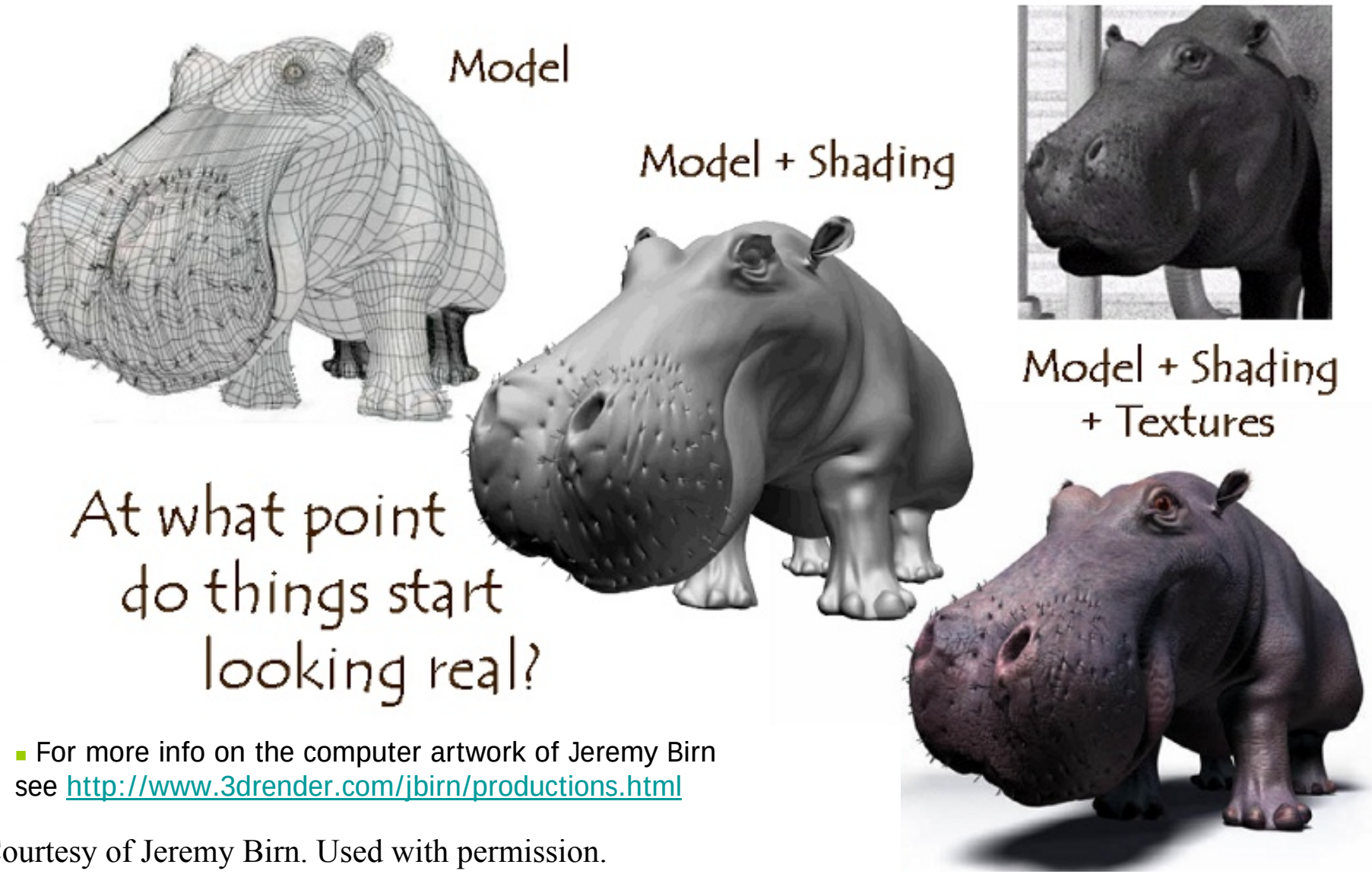
Textures and shading



- For more info on the computer artwork of Jeremy Birn see http://www.3drender.com/jbirn/productions.html

shadows

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Image removed due to copyright considerations.

Traditional Ray Tracing

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Ray Tracing+soft shadows

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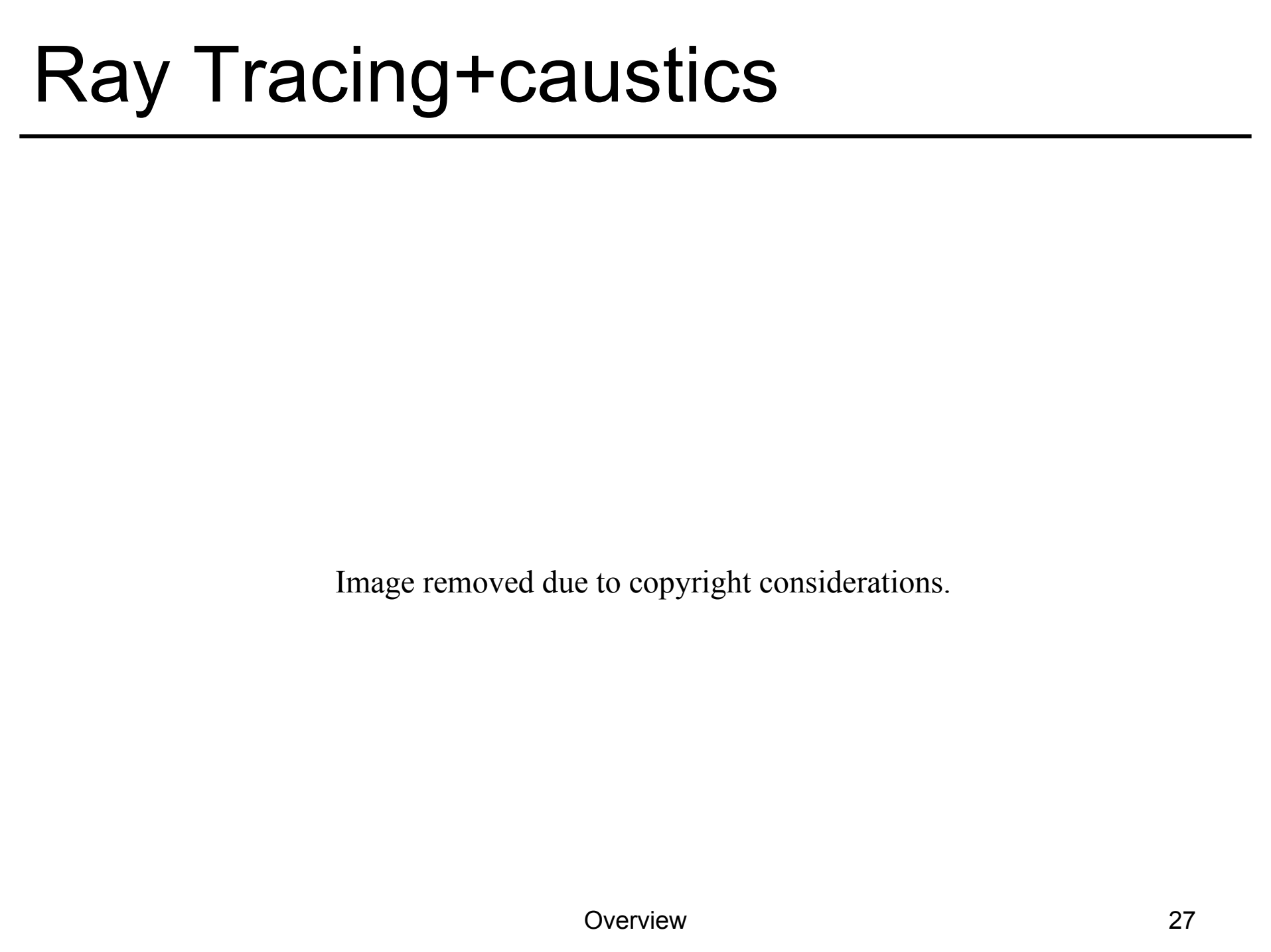
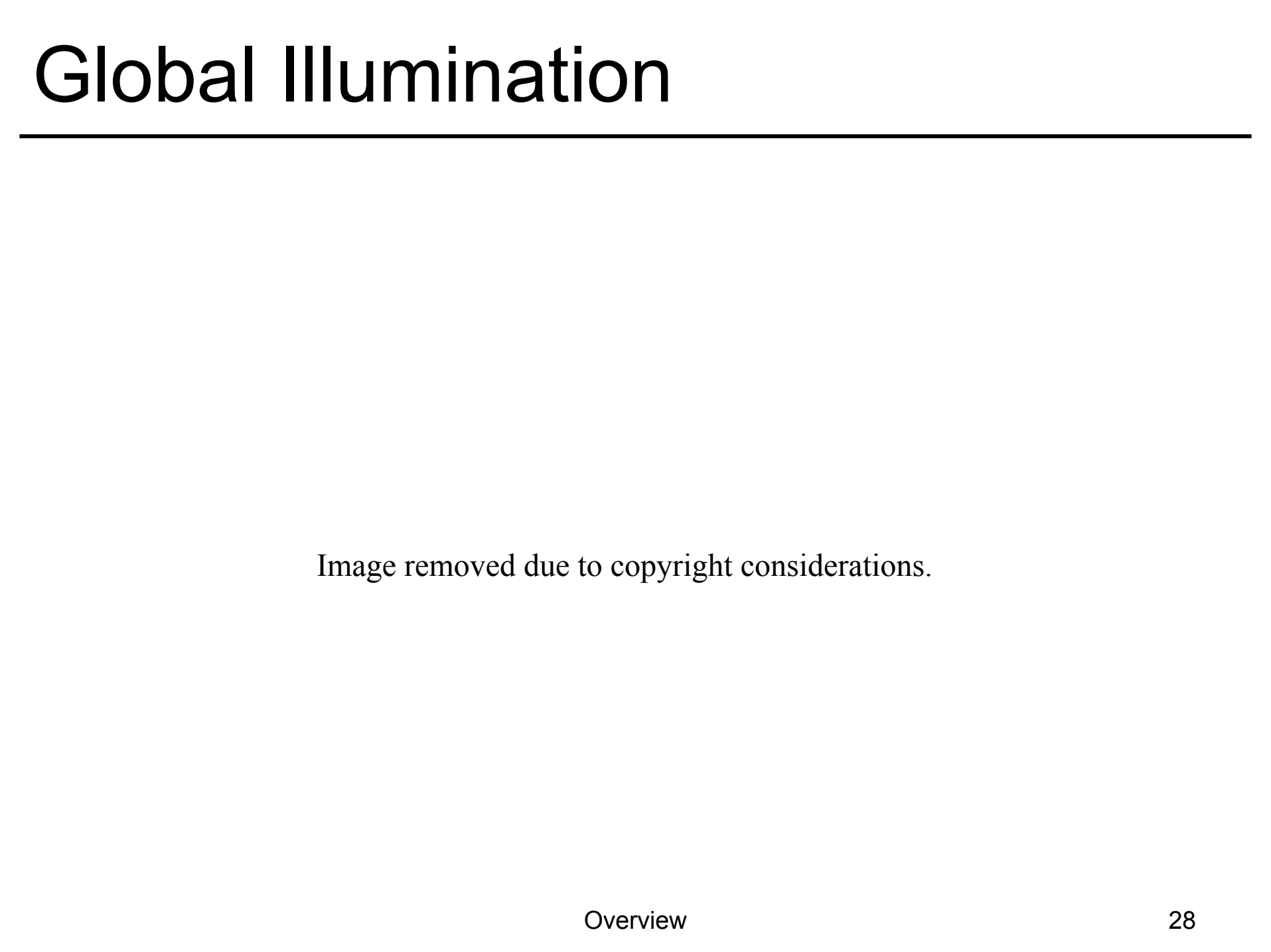
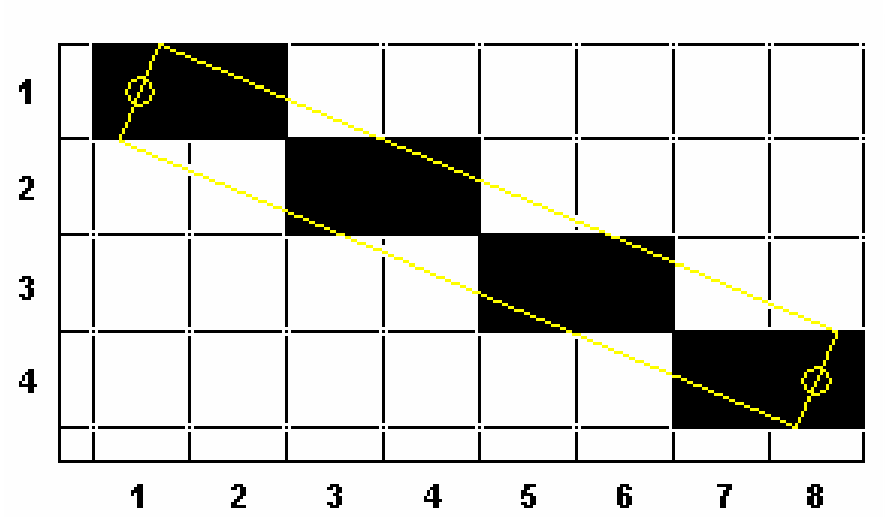
Ray Tracing+caustics

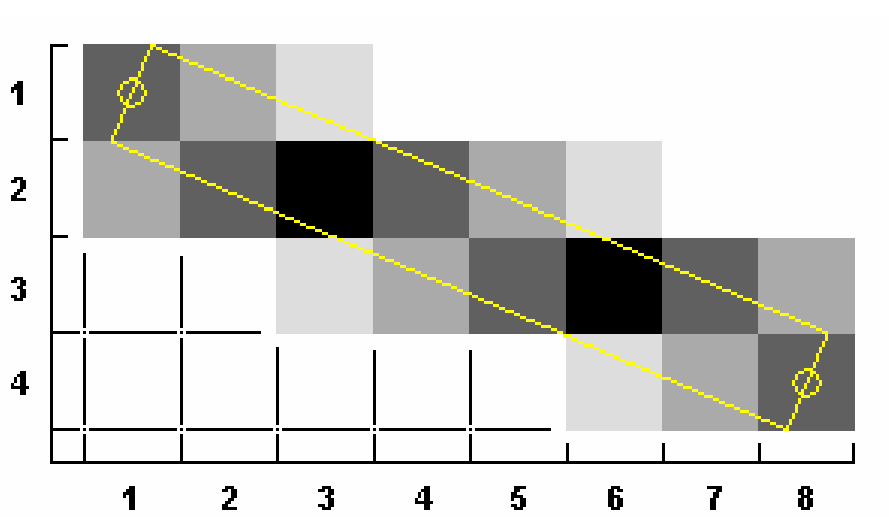


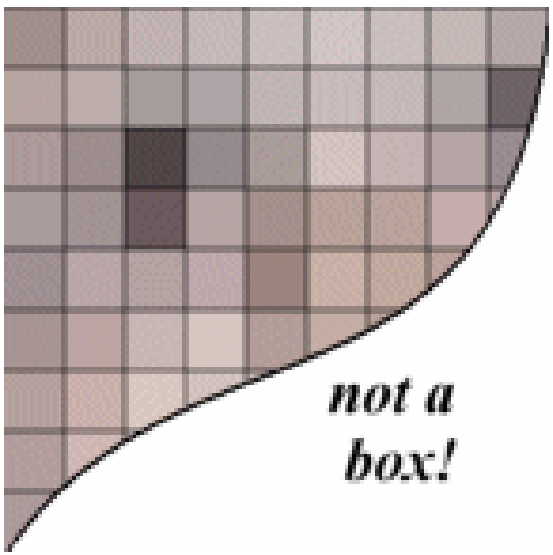
Global Illumination

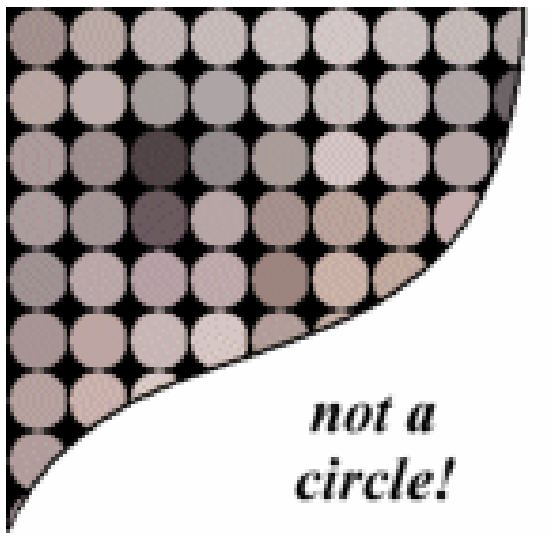


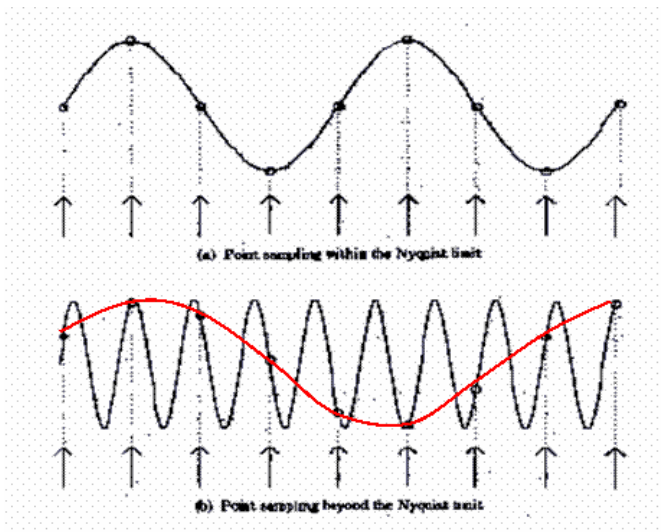
Antialiasing











Questions?

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Administrivia

- Web: http://graphics.csail.mit.edu/classes/6.837/F03/
- Lectures
  - Slides will be online
- Office hours
  - Posted on the web
- Review sessions
  - C++, linear algebra

Prerequisites

- Not enforced
- 18.06 Linear Algebra
  - Simple linear algebra, vectors, matrices, basis, solving systems of equations, inversion
- 6.046J Algorithms
  - Orders of growth, bounds, sorting, trees
- C++
  - All assignments are in C++
  - Review/introductory session Monday

Grading policy

- Assignments: 40%
  - Must be completed individually
  - No late policy. Stamped by stellar.
- 2 Quizzes: 20%
  - 1 hour in class
- Final project: 40%
  - Groups of 3, single grade for the group
  - Initial proposal: 3-5 pages
  - Steady weekly progress
  - Final report & presentation
  - Overall technical merit

Assignments

- Turn in code AND executable
- We will watch code style
- Platform
  - Windows
  - Linux
- Collaboration policy:
  - You can chat, but code on your own
- No late policy

Project

- Groups of 3
- Brainstorming
  - Middle of the semester
- Proposal
- Weekly meeting with TAs
- Report & presentation

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IFS: self-similar fractals

- Described by a set of *n* transformations *fi*
  - Capture the self-similarity
  - Affine transformations
  - Contractions (reduce distances)
- An attractor is a fixed point

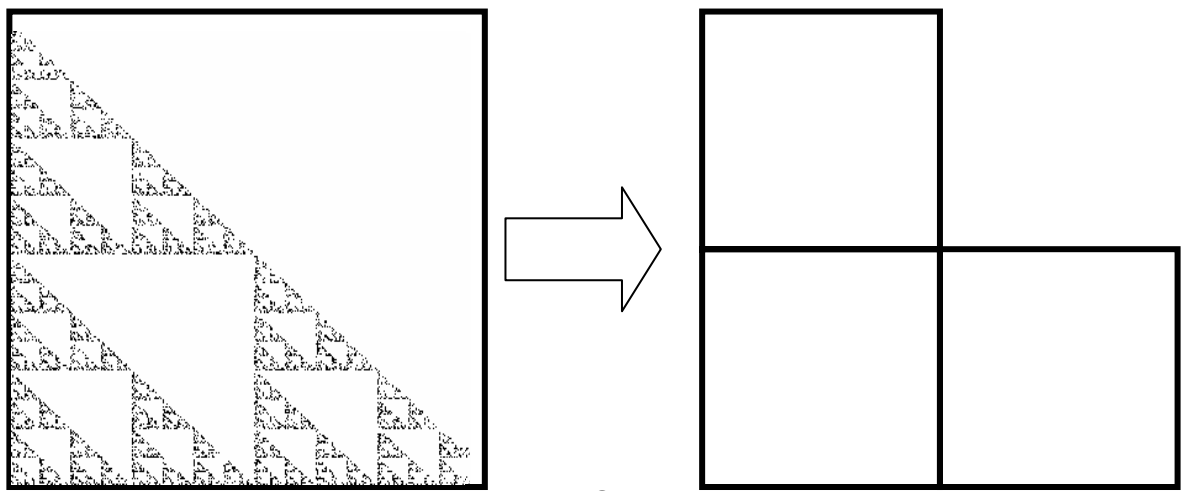
$$A = \bigcup f_i(A)$$

Image removed due to copyright considerations.

Image from http://spanky.triumf.ca/www/fractal-info/ifs-type.htm

Example: Sierpinsky triangle

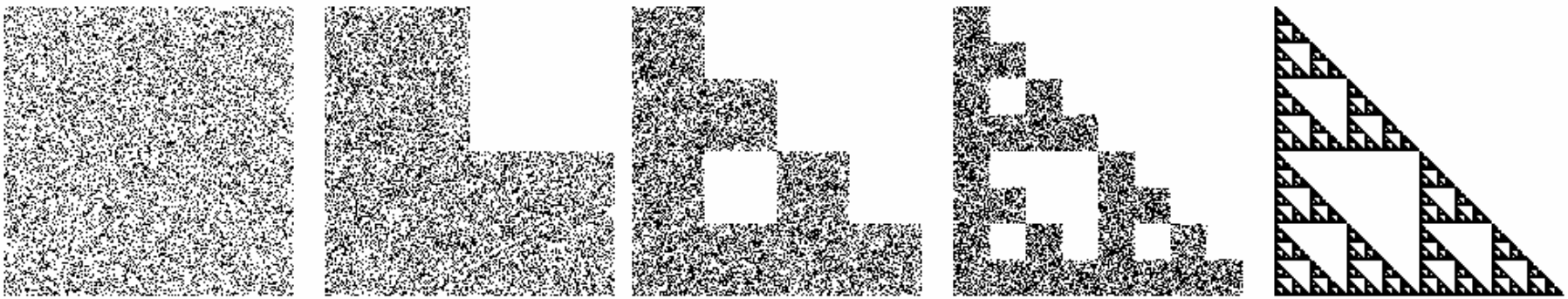
- 3 transforms
- Translation and scale by 0.5



Rendering

```
For a number of random input points (x0, y0)
    For j=0 to big number
        Pick transformation i
            (xk+1, yk+1) = fi (xk, yk)
    Display (xk, yk)
```

- Probabilistic application of one transformation



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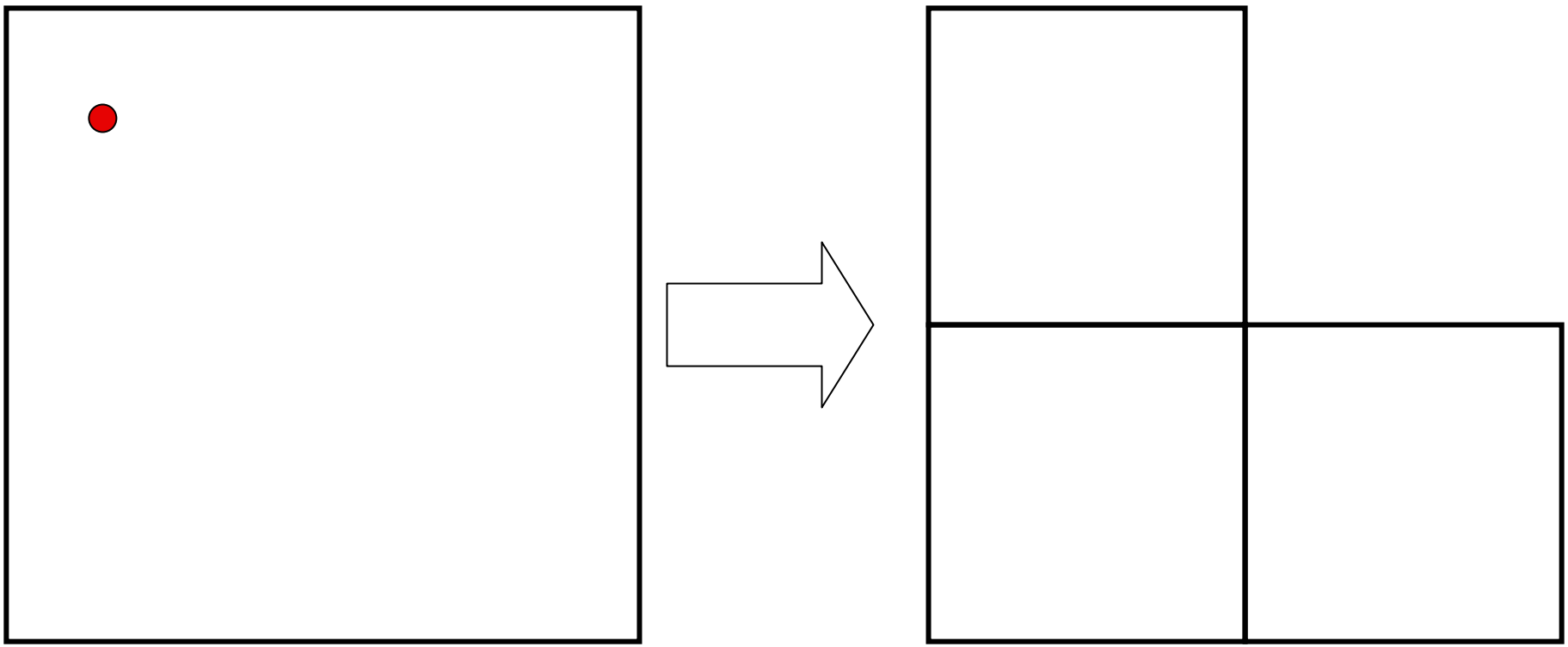

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For a number of random input points (x_0, y_0)

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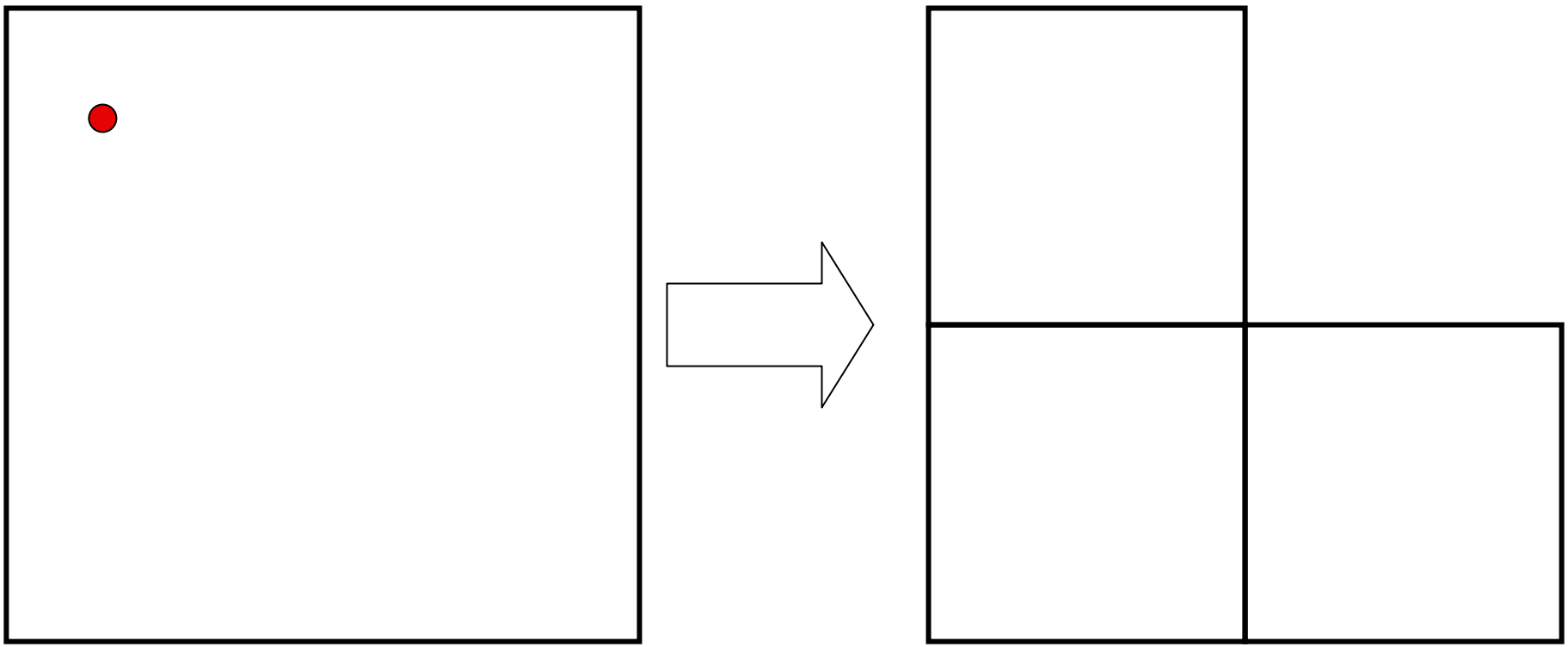

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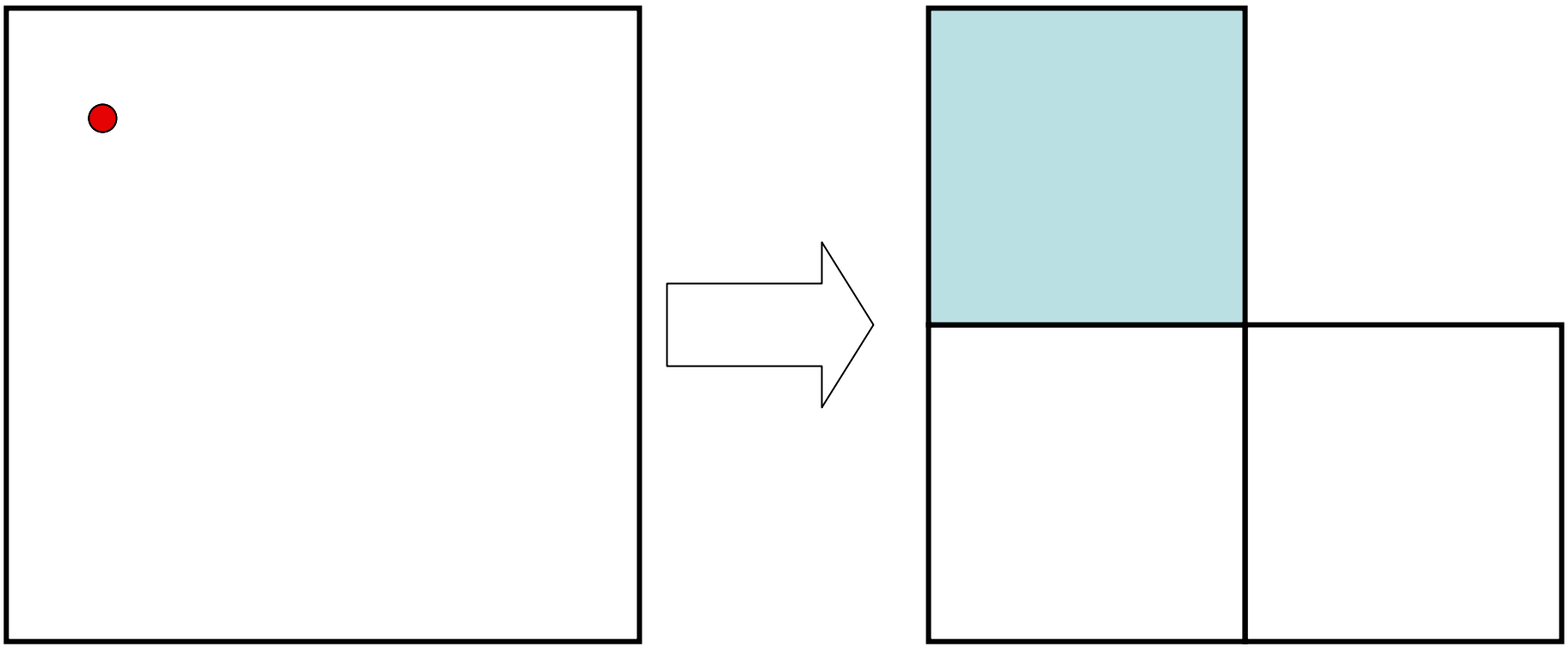

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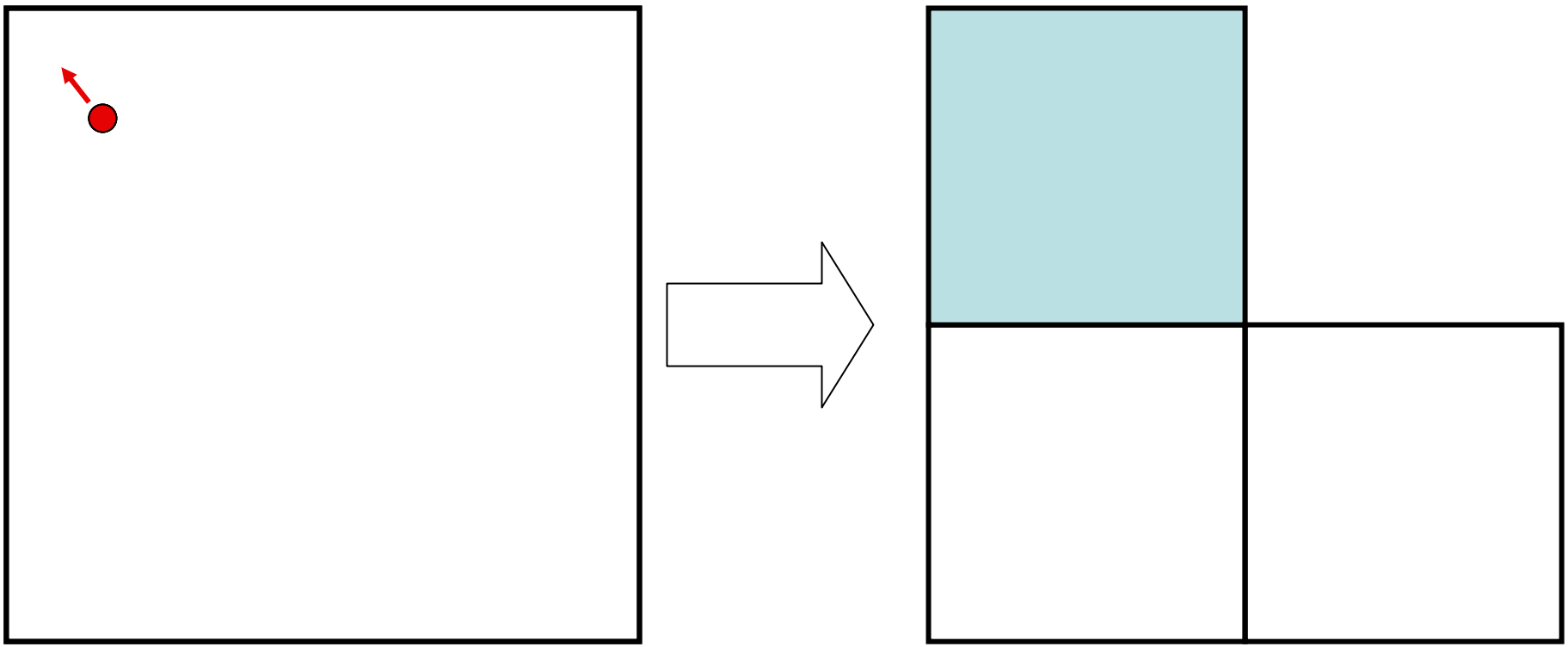

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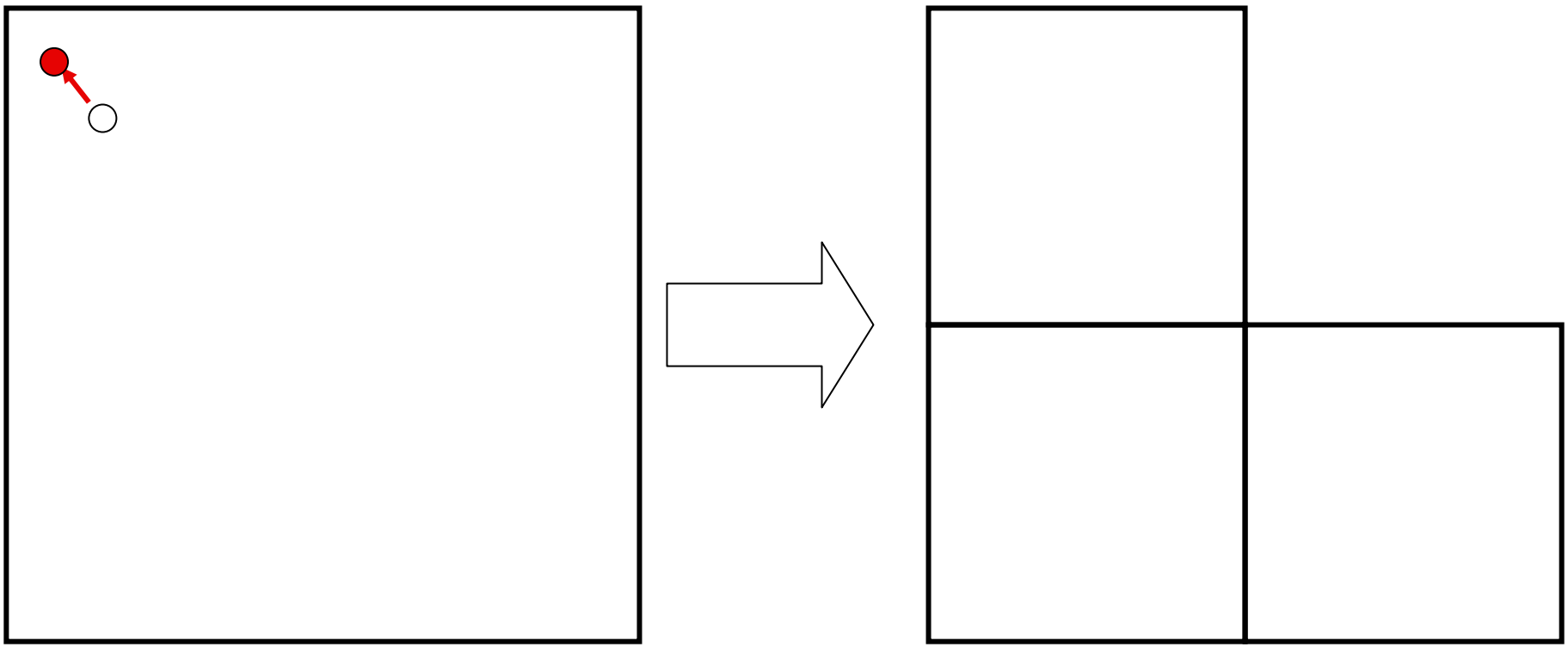

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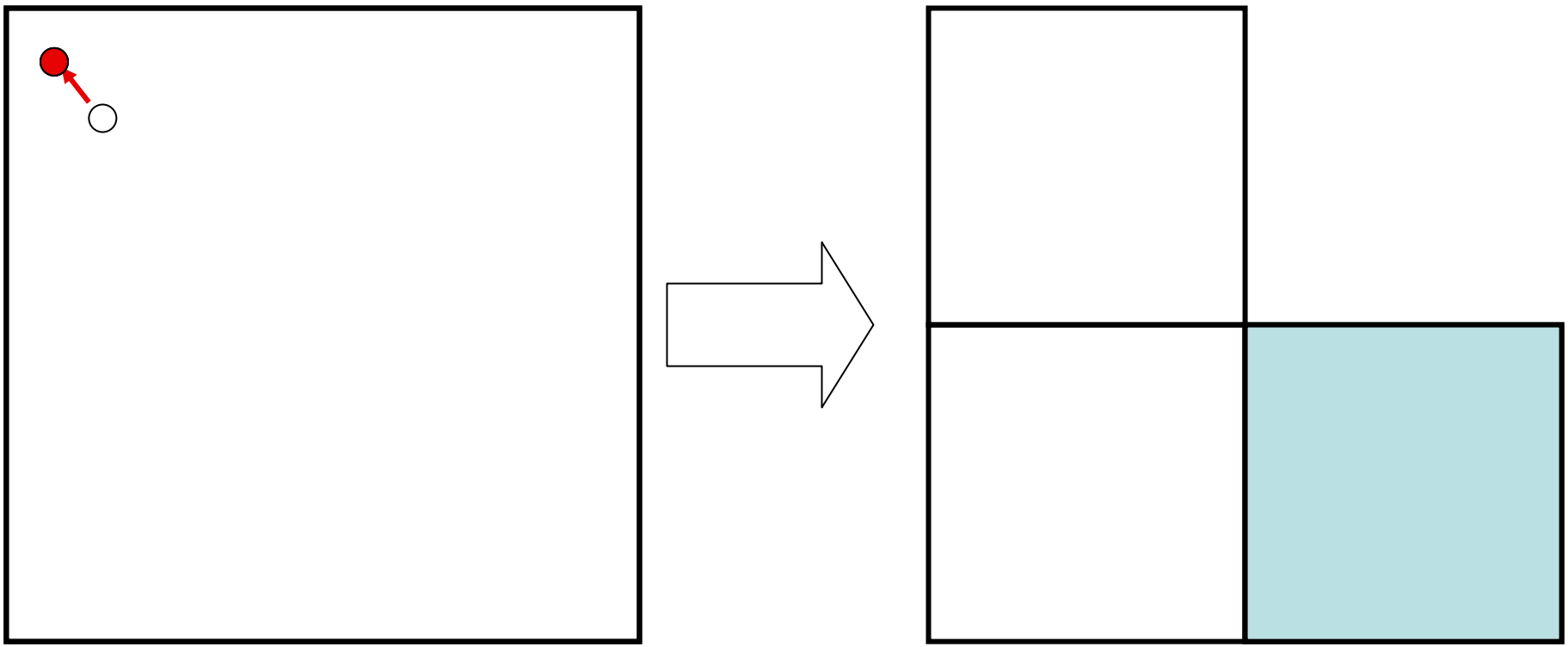

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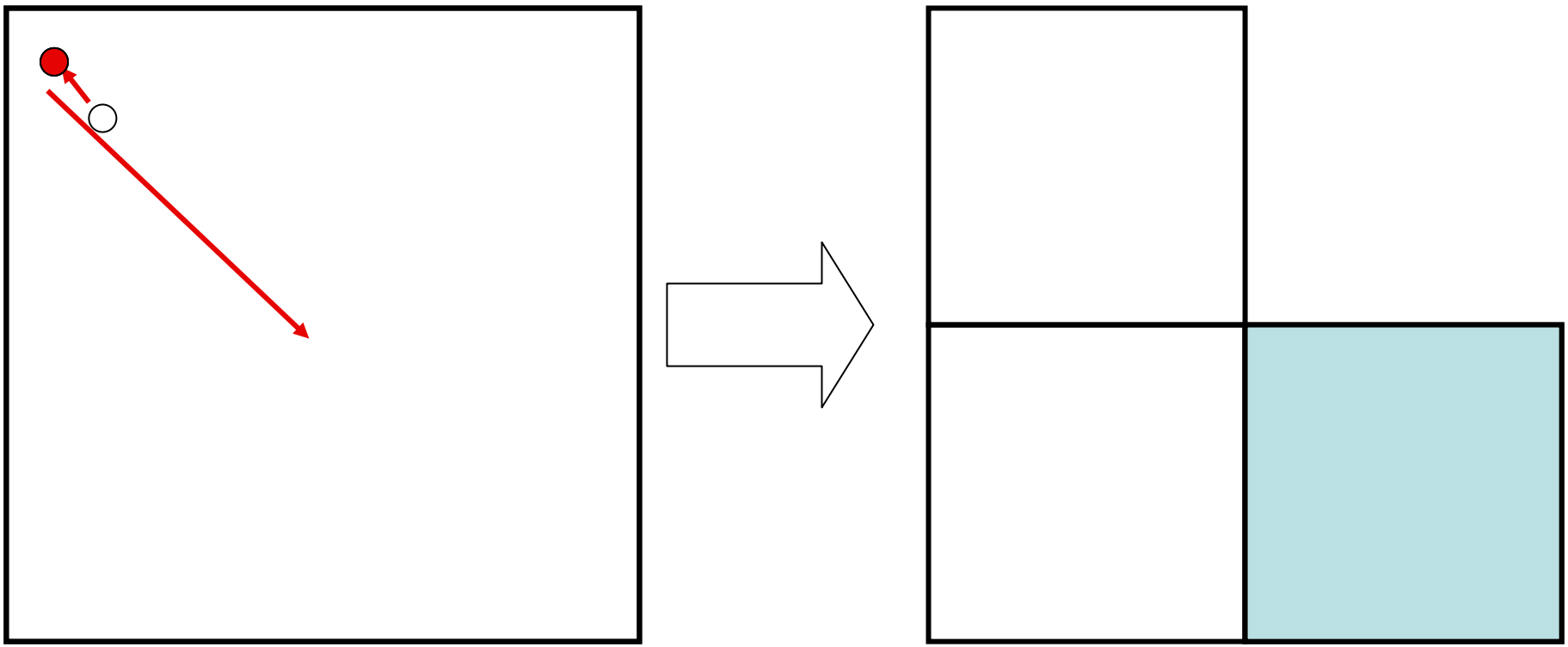

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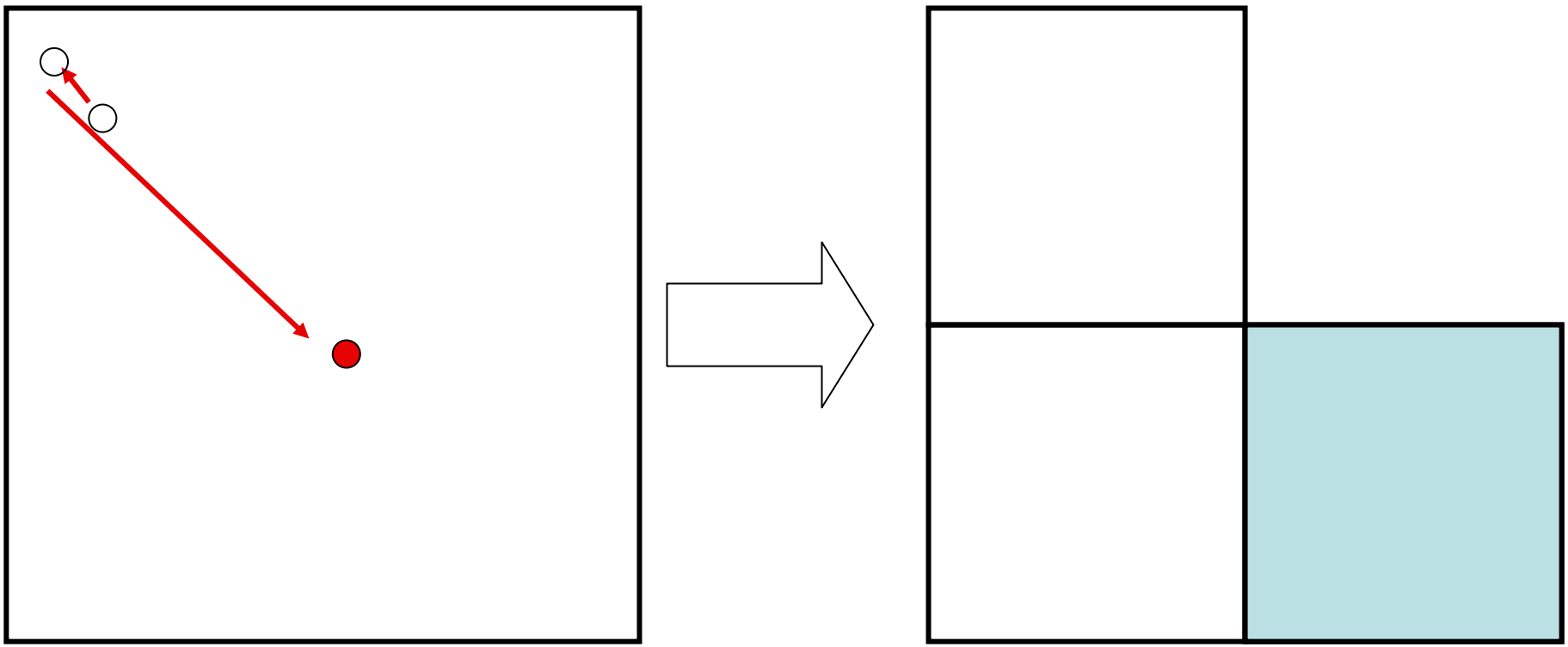

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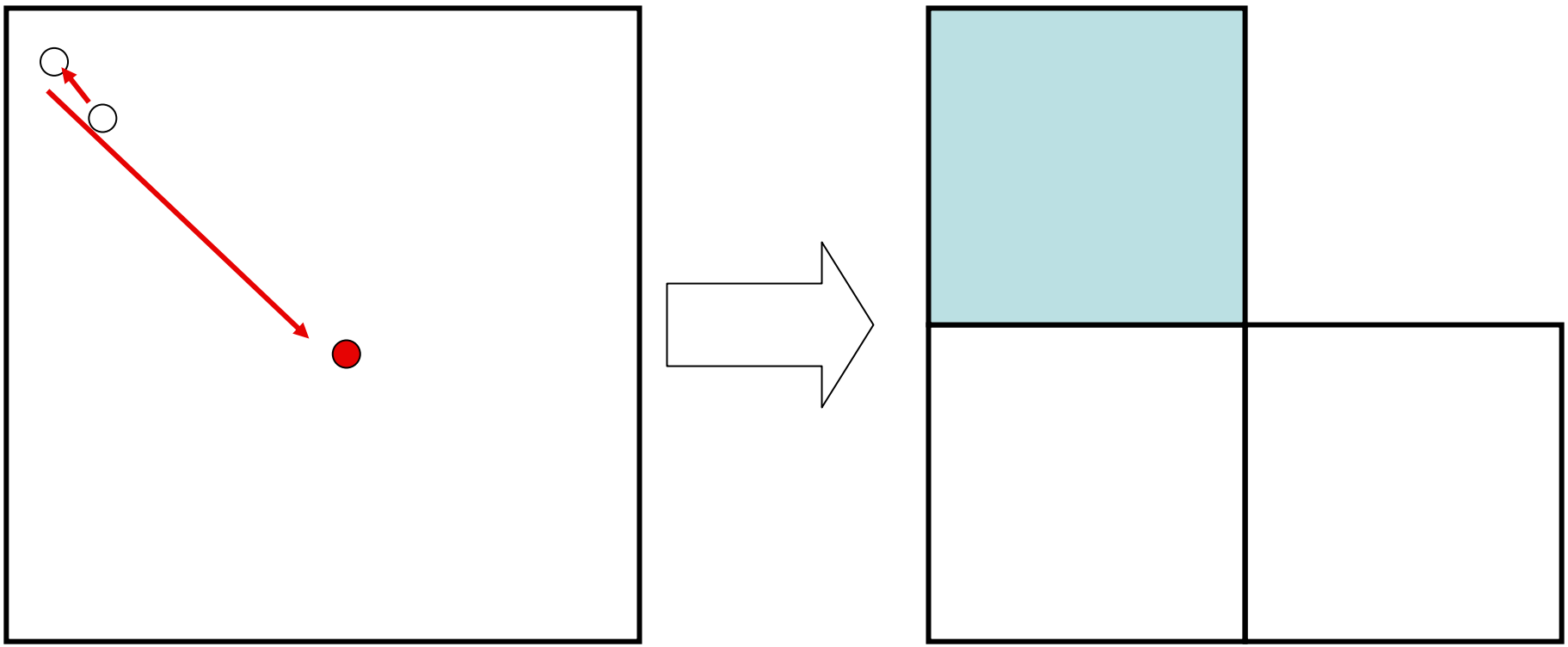

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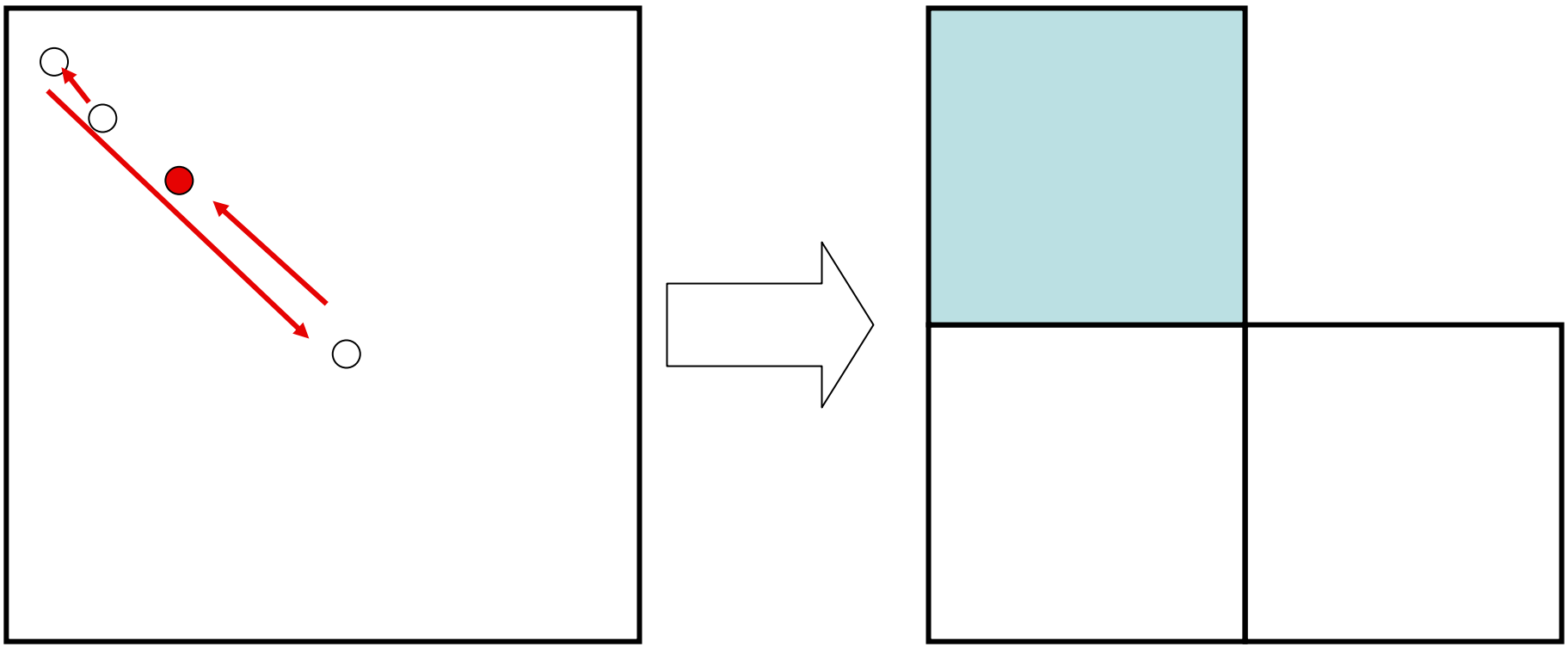

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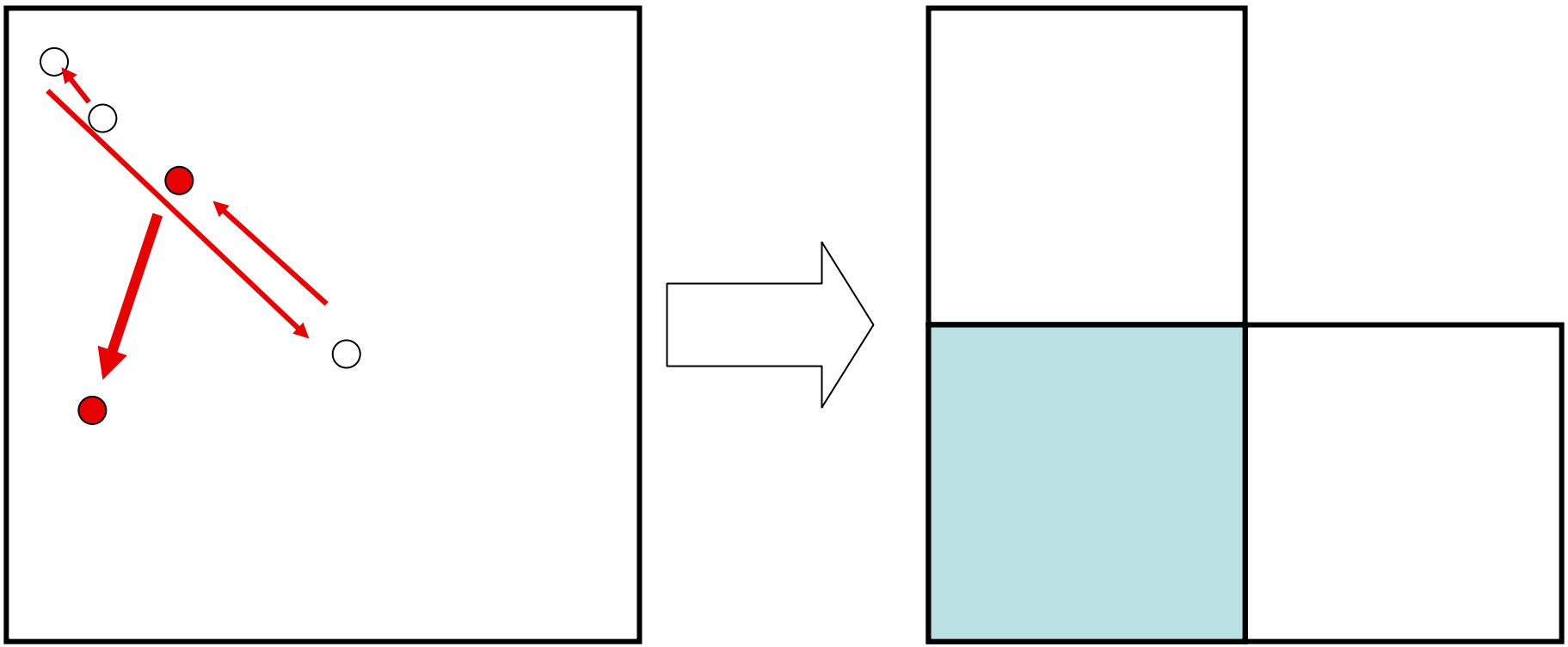

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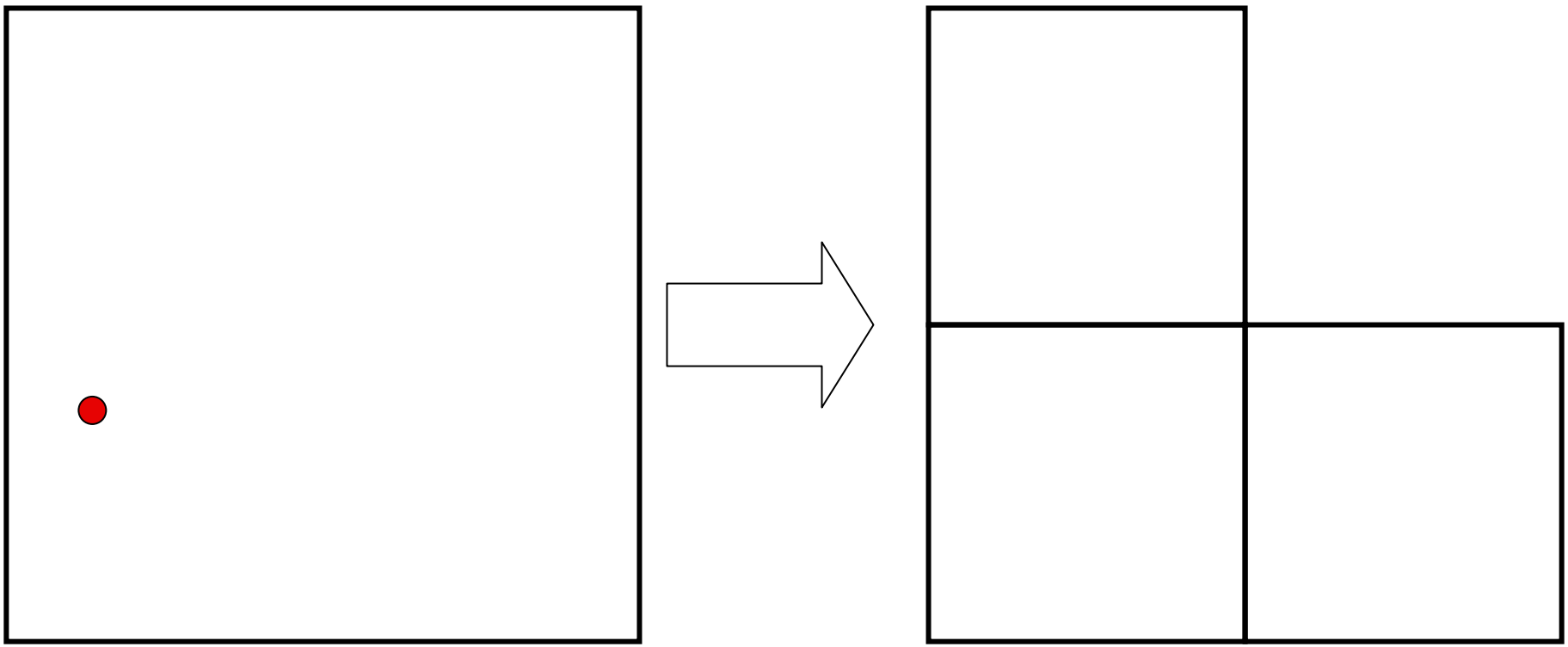

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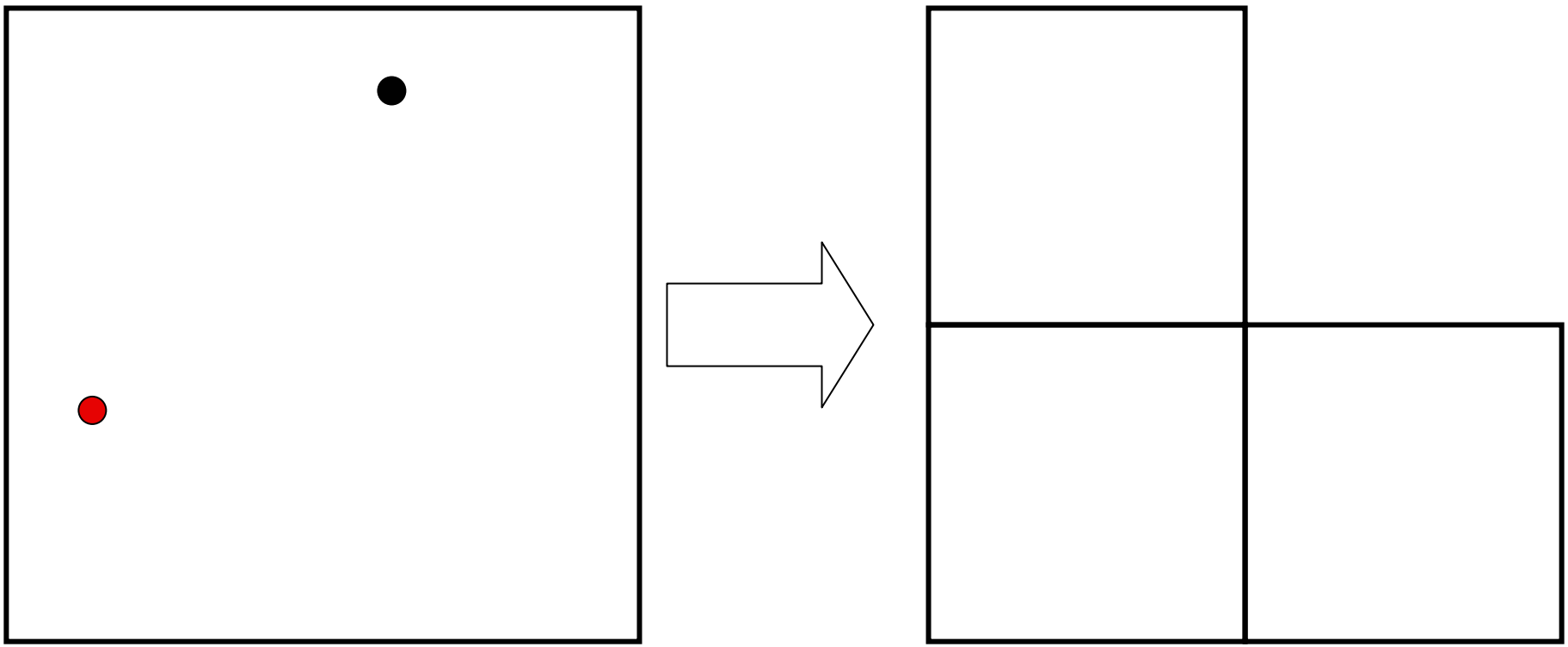

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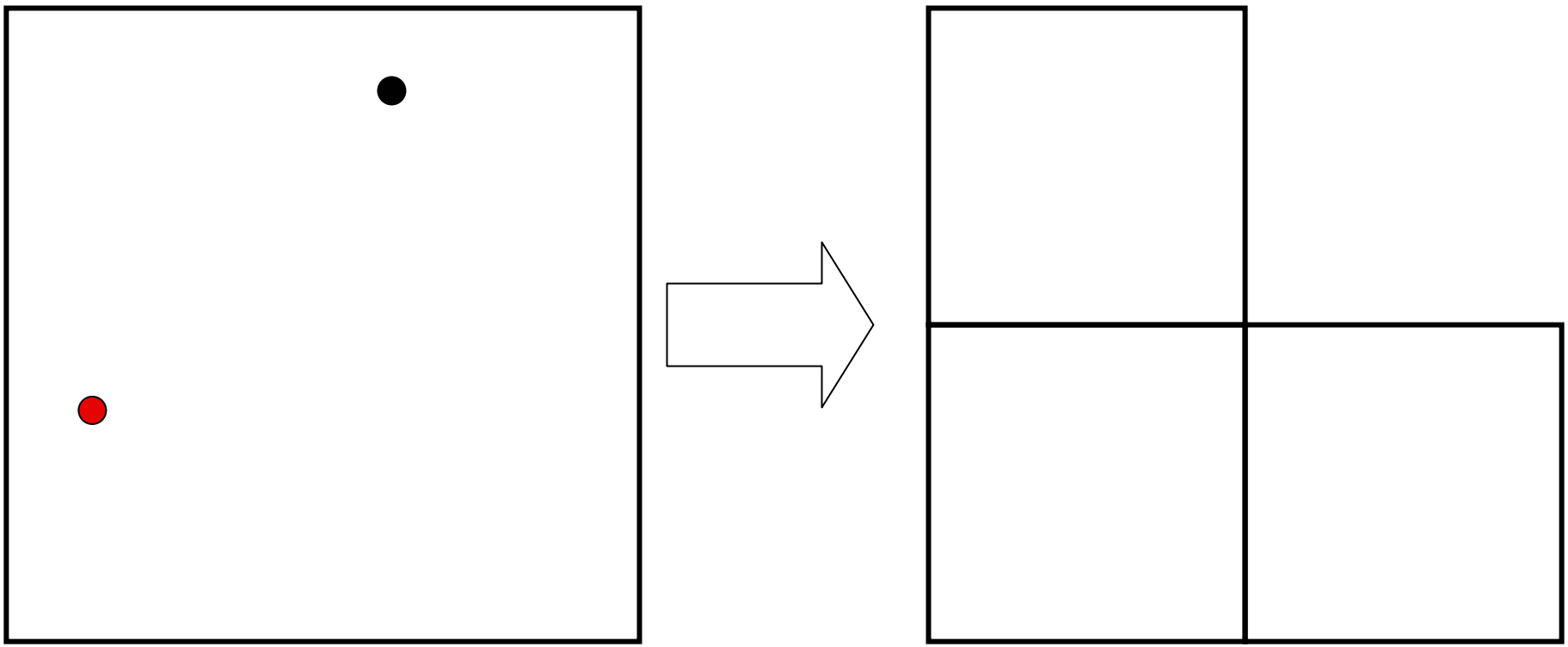
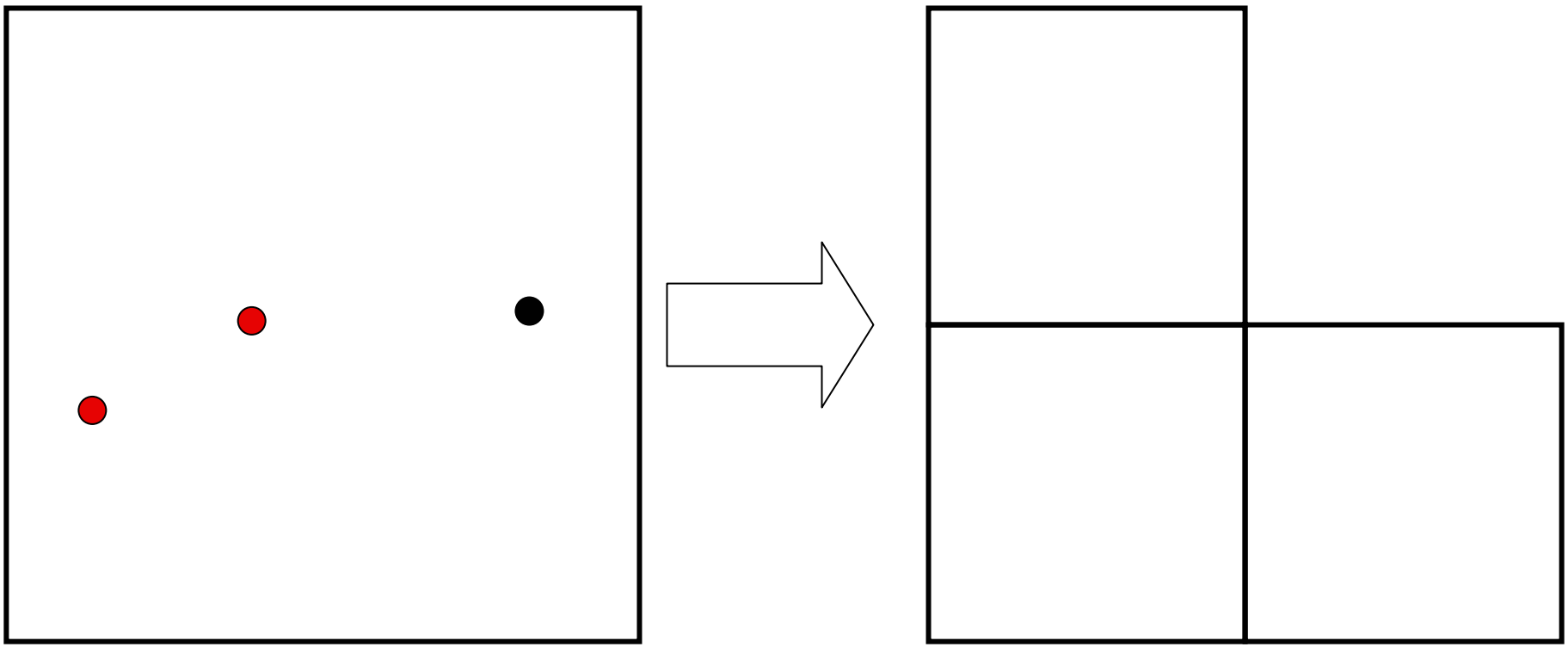


Example: Sierpinsky triangle

For a number of random input points (x_0, y_0)

```
    For j=0 to big number
        Pick transformation i
            (x_{k+1}, y_{k+1}) = f_i (x_k, y_k)
    Display (x_k, y_k)
```



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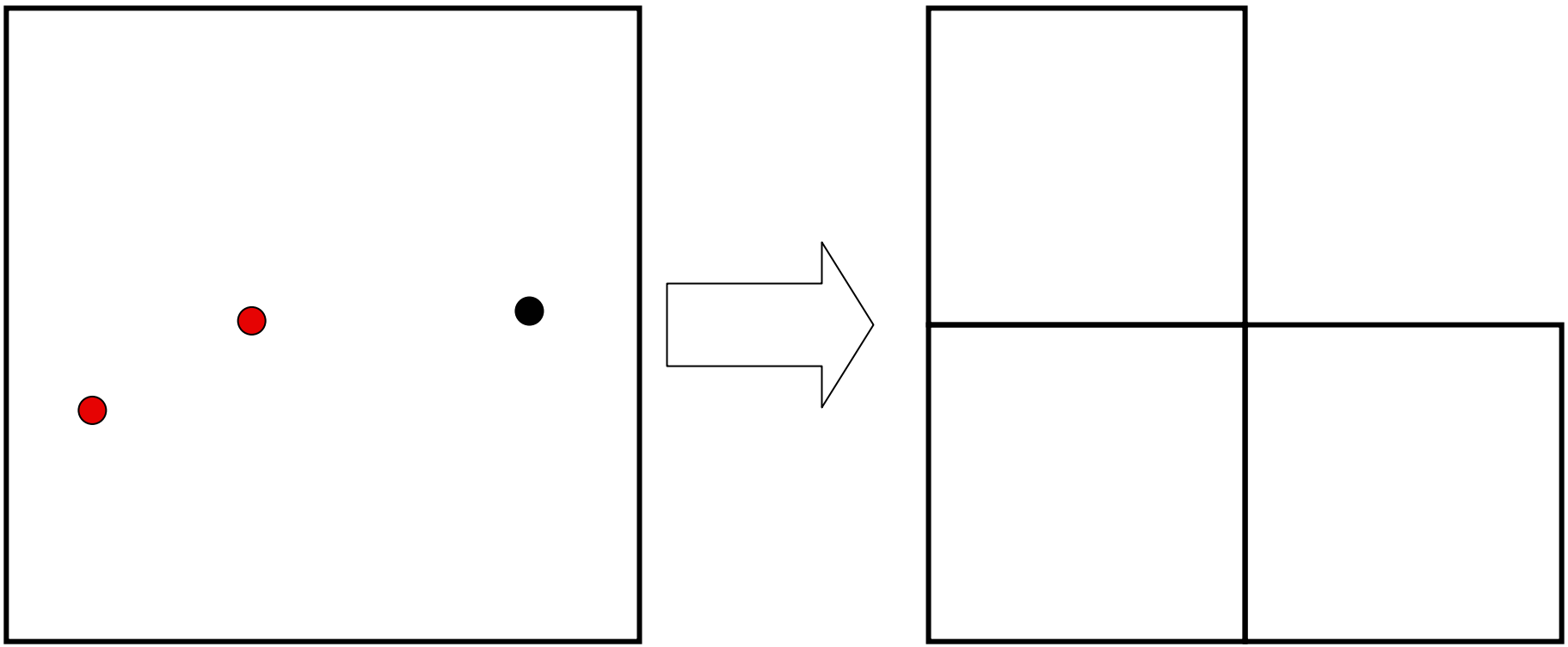

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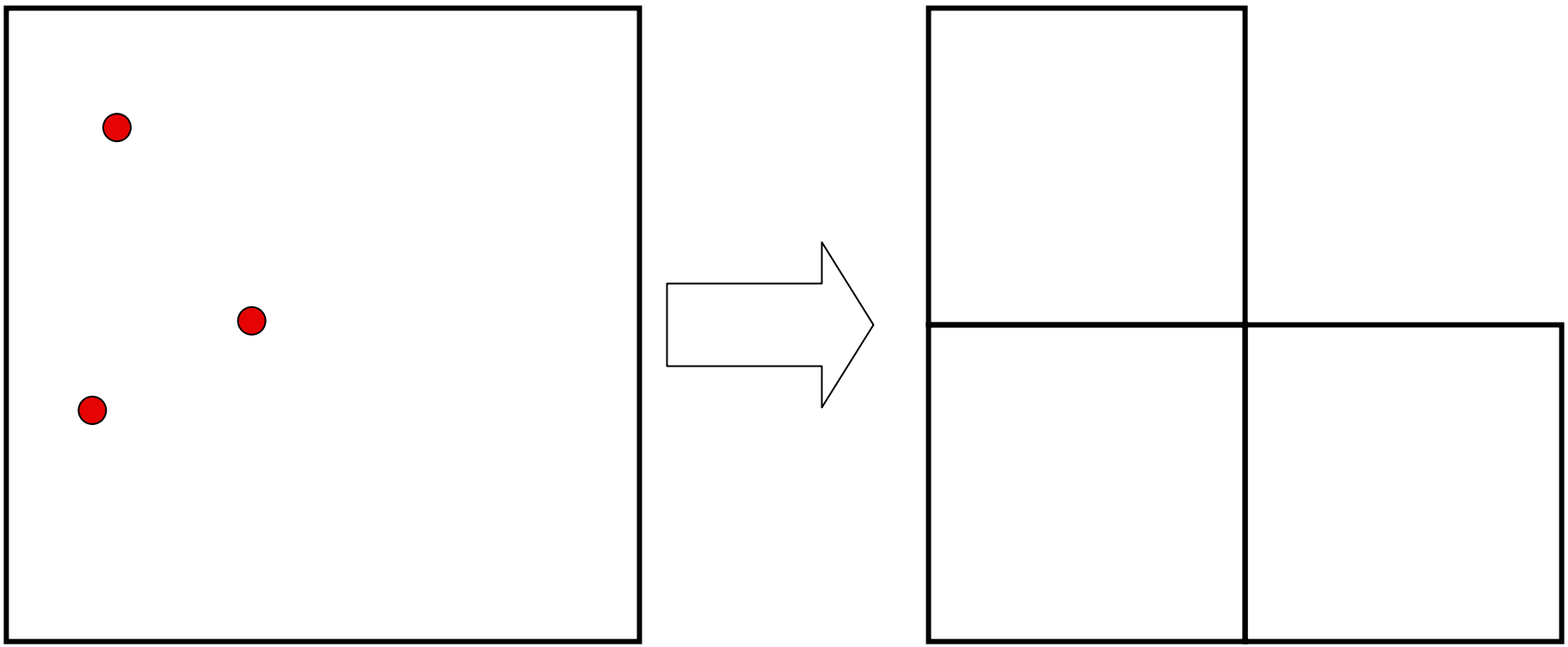

Example: Sierpinsky triangle

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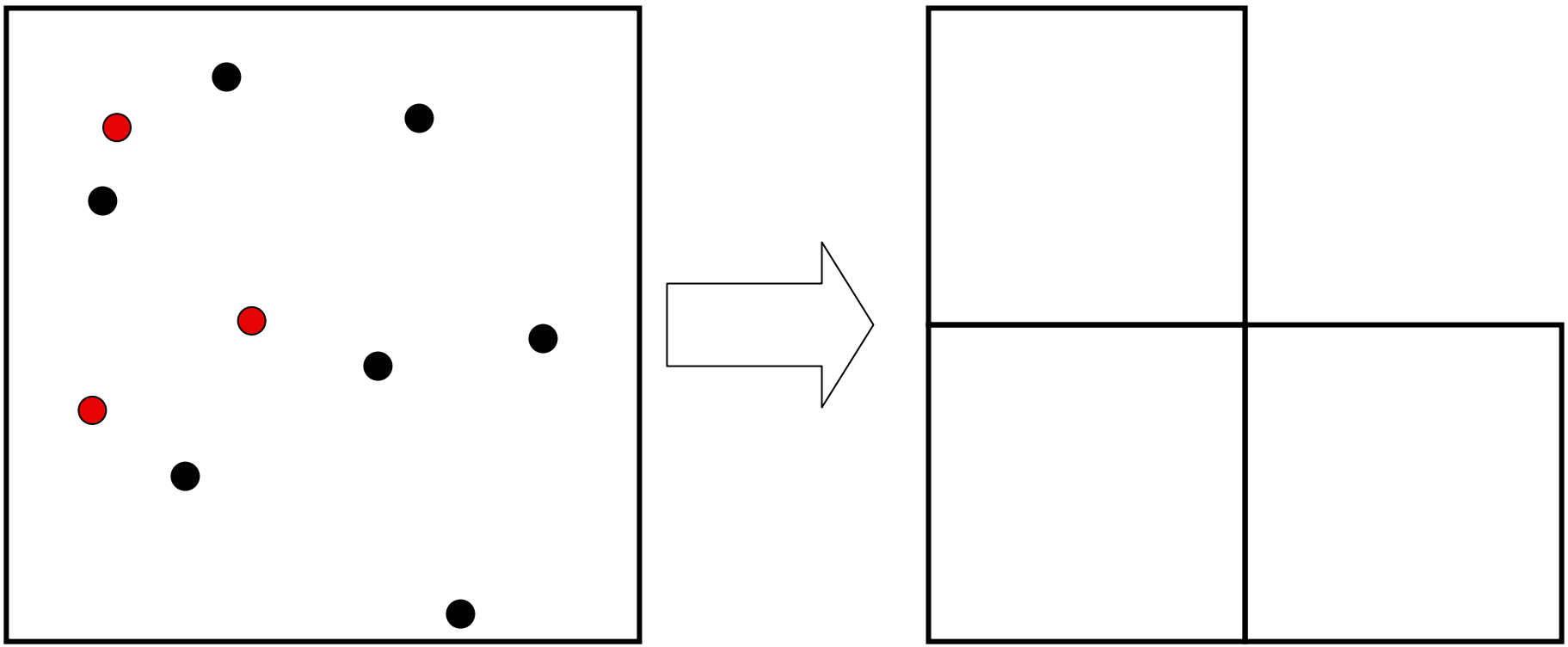
    For j=0 to big number
        Pick transformation i
            (xk+1, yk+1) = fi (xk, yk)
    Display (xk, yk)
```



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    For j=0 to big number
        Pick transformation i
            (xk+1, yk+1) = fi (xk, yk)
    Display (xk, yk)
```
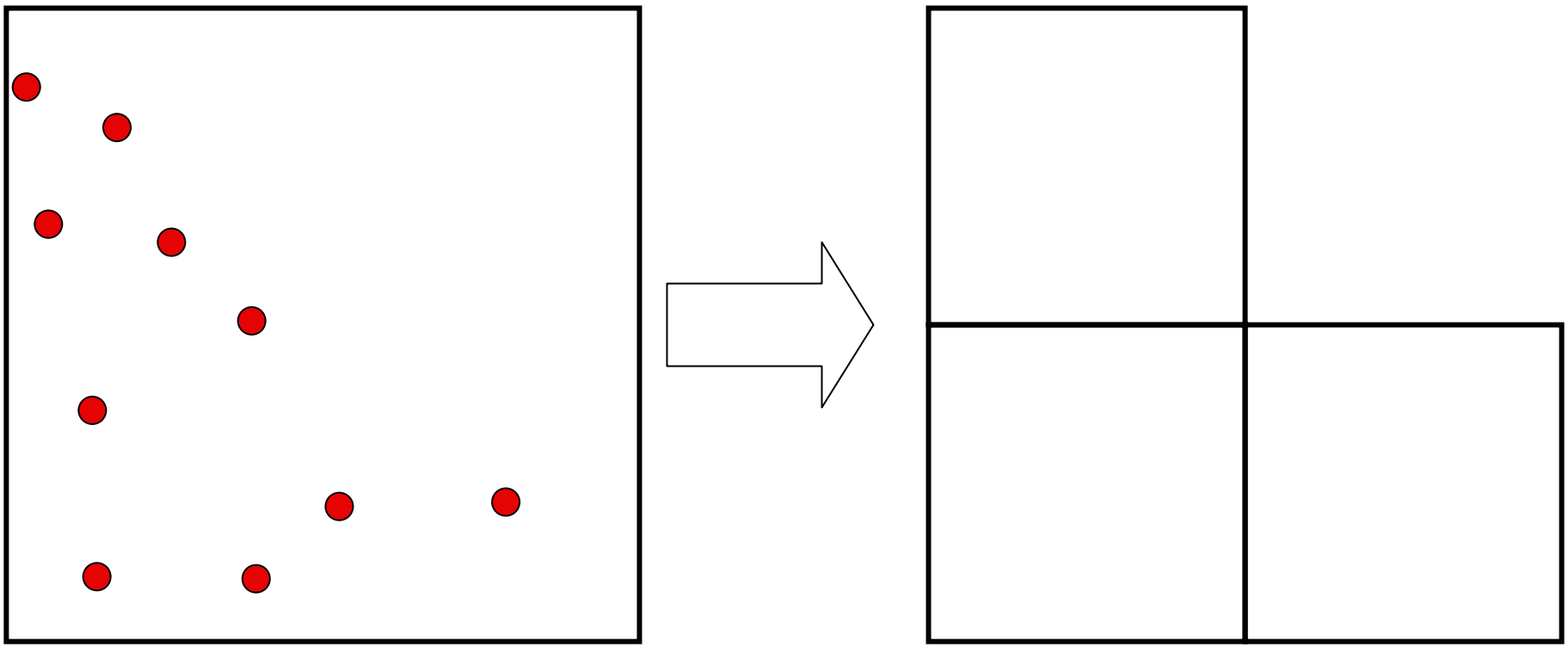



Example: Sierpinsky triangle

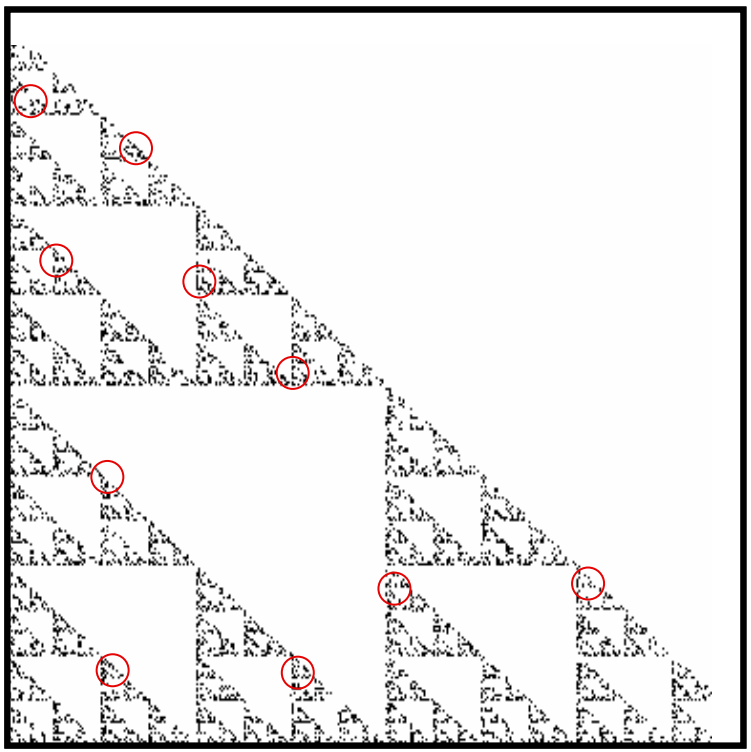
For a number of random input points (x_0, y_0)

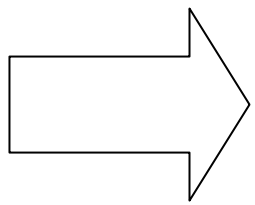
For j=0 to big number

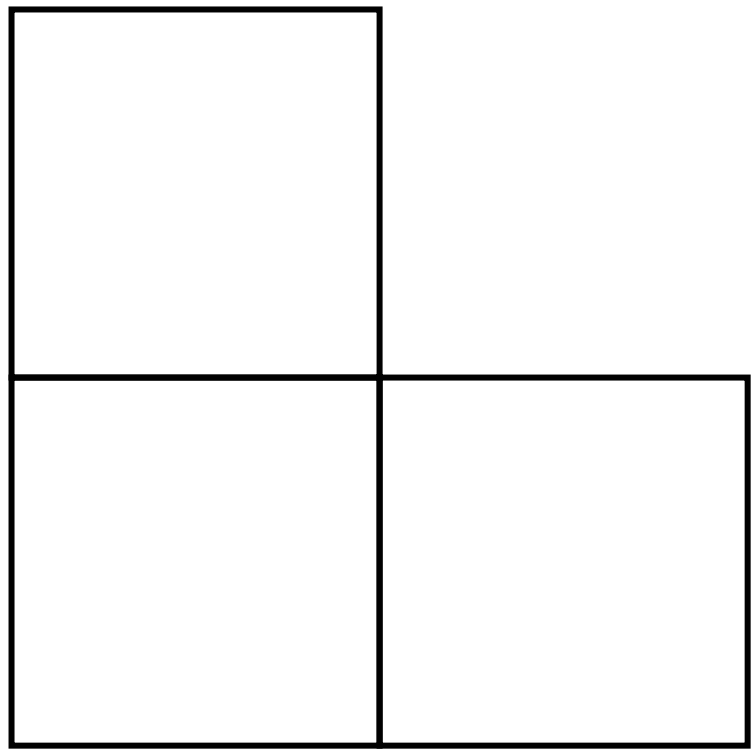
Pick transformation i

$(x_{k+1}, y_{k+1}) = f_i\ (x_k, y_k)$

Display (x_k, y_k)

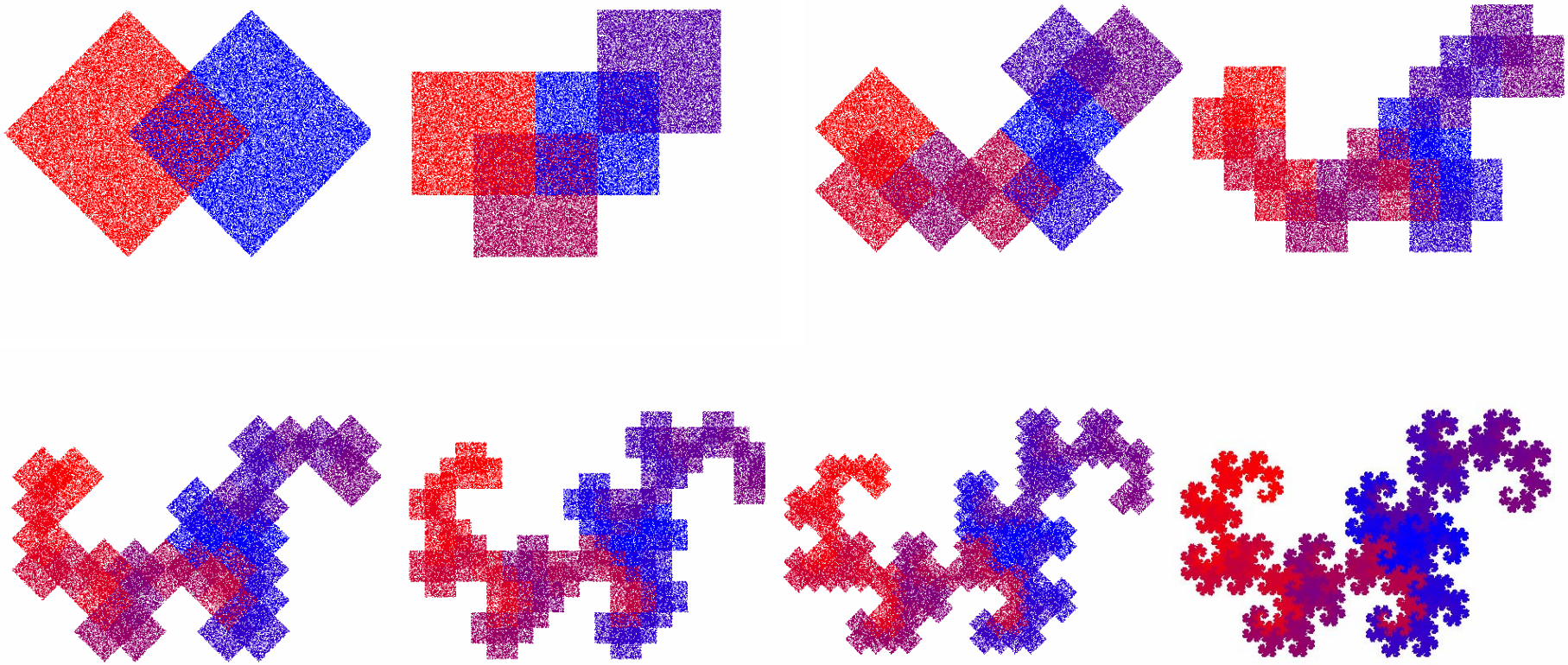






Other IFS

- The Dragon



Application: fractal compression

- Exploit the self-similarity in an image
- E.g. http://fractales.inria.fr/index.php?page=img_compression

Assignment: IFS

- Write a C++ IFS class
- Get familiar with
  - vector and matrix library
  - Image library
- Due Wednesday at 11:59pm

- Check on the web page

http://graphics.lcs.mit.edu/classes/6.837/F03/

Review/introduction session: C++

- Monday 7:30-9

Questions?