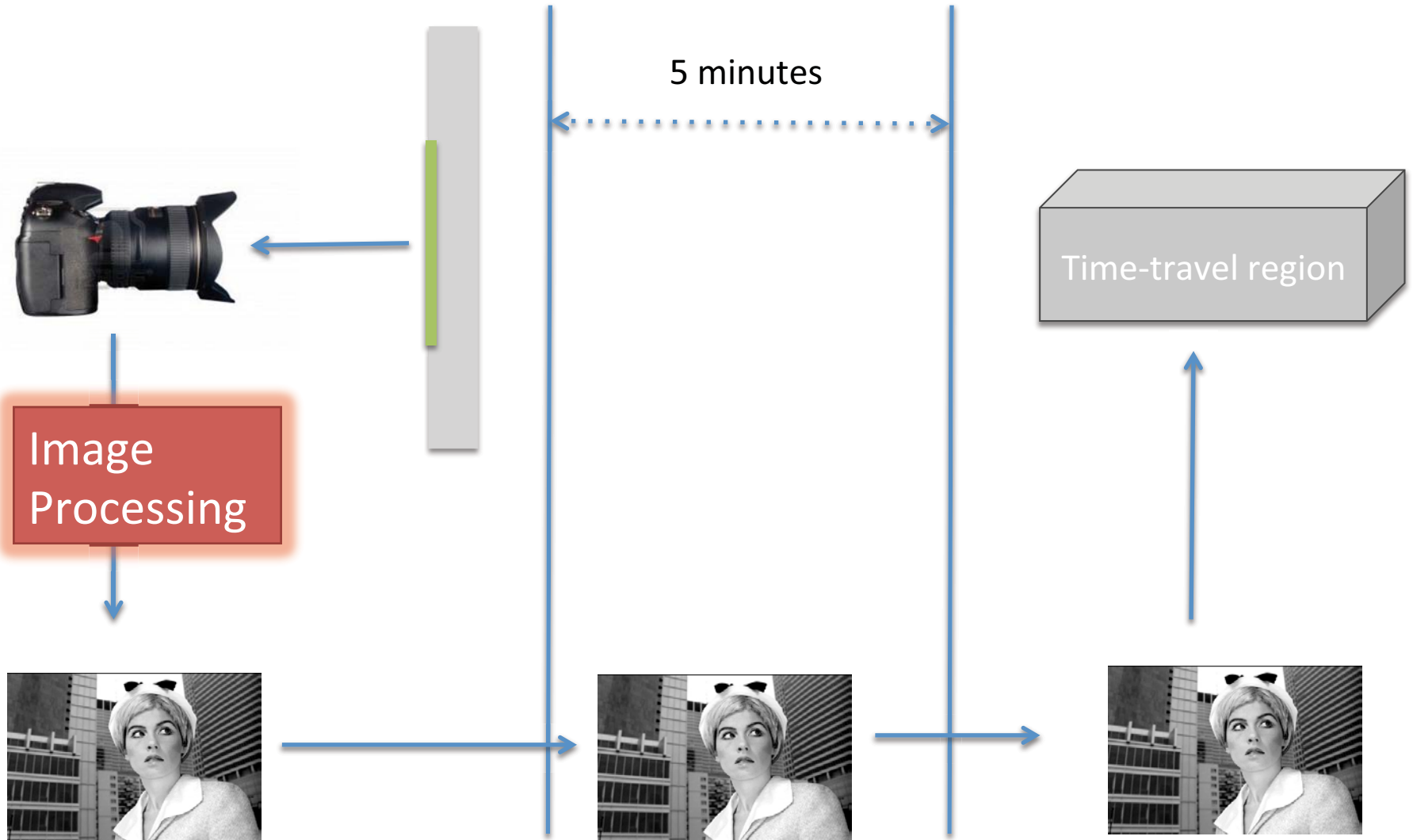


# Time Travel Section

Owain Evans, MIT 24.118

t1:  
Photo arrives from future and is captured by camera

t2:  
Developed by photo is placed in time-travel region



# Toy Model of CTC: Assumptions

- **Time t1:**
  - i. Photo arrives from future.
  - ii. The photo is photographed.
  - iii. The original disintegrates.
- **Between t1 and t2:**
  - After image processing, new photo is printed.
- **Time t2:**
  - New photo is put into time-travel region
- The process is automated and no humans are able to intervene.

# Case 1: Analog Image and Analog Camera that Inverts Image

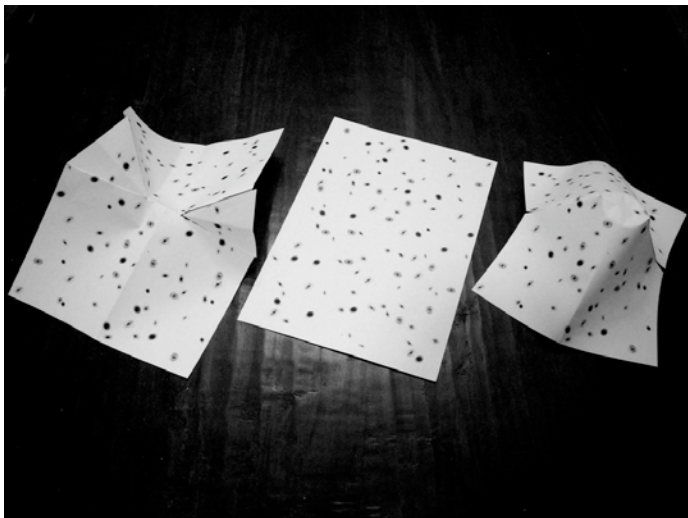


Image courtesy of [Wafer X](#) on Flickr. Available CC BY.

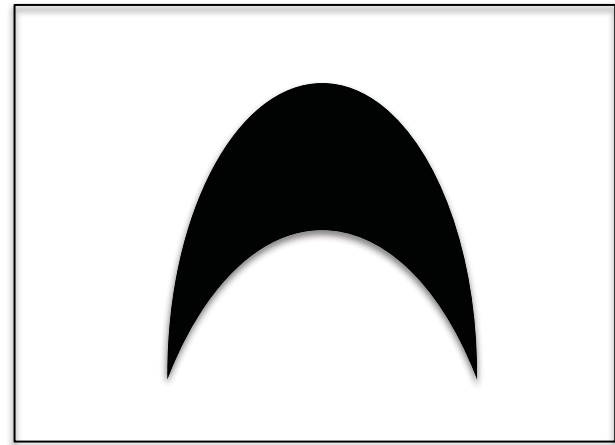
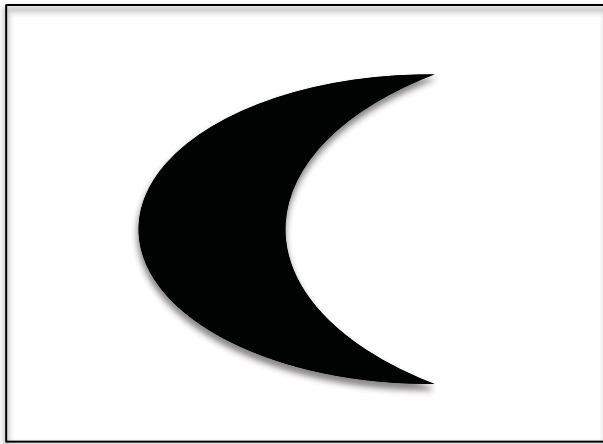


Image courtesy of [Wafer X](#) on Flickr. Available CC BY.

# Case 2: Digital Image and Pixel Flip Camera



# Case 3: Digital Image and 90 degree rotation

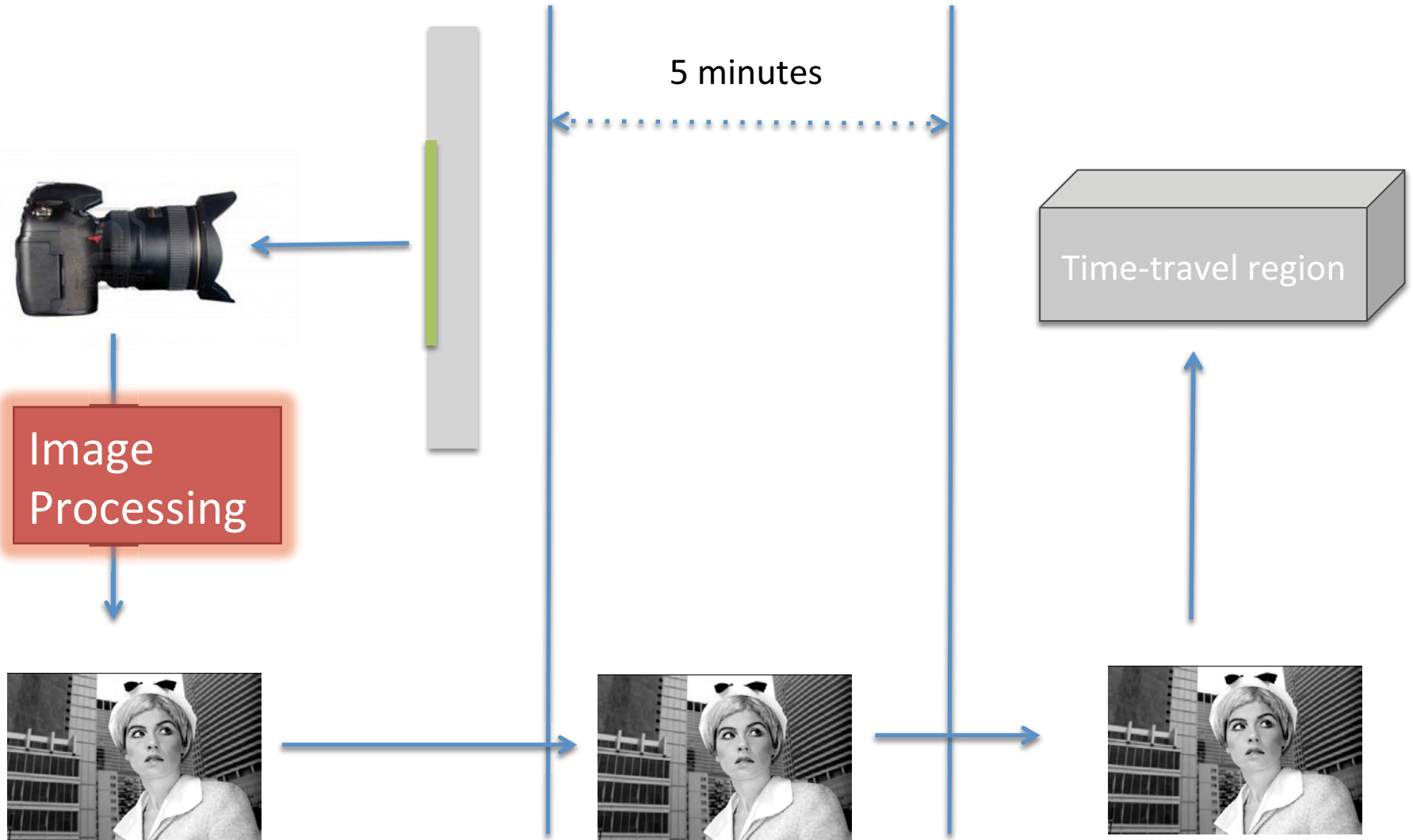


# Theory: Fixed-point Theorems

- Analog Camera: Each pixel is real number on  $[0,1]$ . Camera is a cts function on each pixel.
- Digital camera: Pixels are bits. Camera is a discrete function on whole image.
- Theory: Many cts functions have no fixed point.
- Theory: All Markov chains have a fixed point.

t1:  
Photo arrives from future and is captured by camera

t2:  
Developed by photo is placed in time-travel region





t1:  
Photo arrives from future and is captured by camera



30 minutes

t2:  
Developed by photo is placed in time-travel region

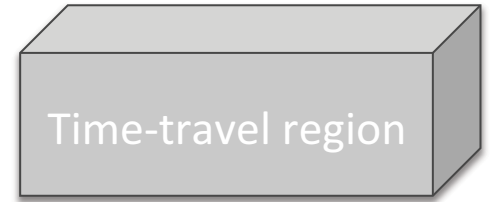


Image courtesy of [Jory](#) on Flickr.  
Available CC BY-NC-SA.



# Can we force nature to solve problems for us?

- IF art critic thinks photo is an **original** masterpiece, then he leaves it unchanged.
- ELSE he will flip some of the pixels.
- Art critic is perfectly systematic: no randomness.

t1:  
Photo arrives from future and is captured by camera

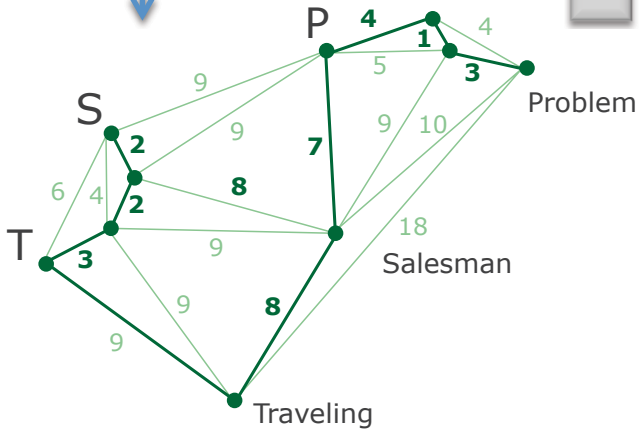
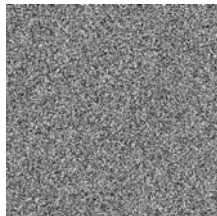
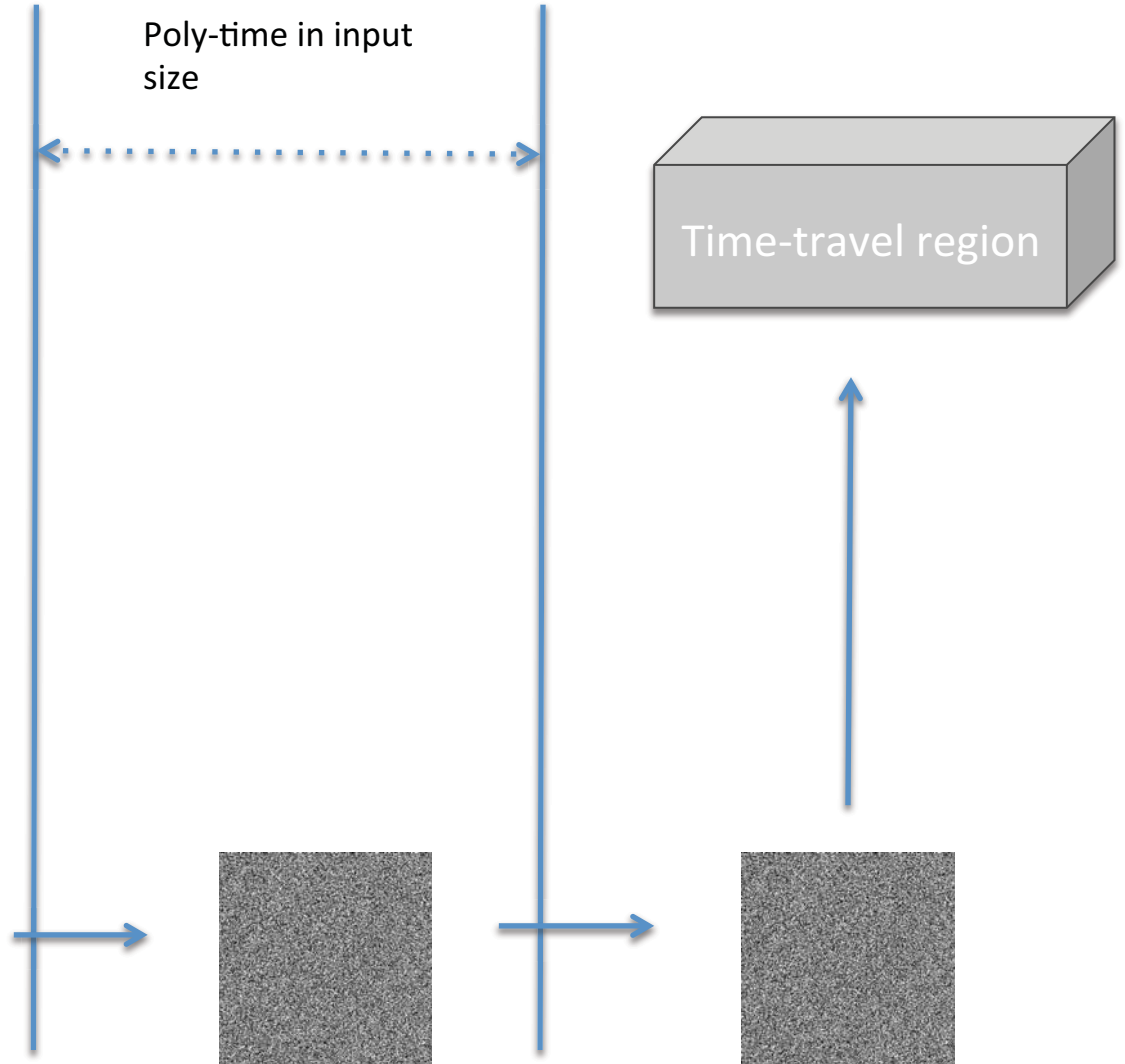


Image by MIT OpenCourseWare.



t2:  
Developed by photo is placed in time-travel region



# Can we force nature to solve problems for us?

- Digital image = binary string. String can encode a series of transitions between nodes in a graph.
- Image is a fixed point iff image encodes a short solution to a Traveling Salesman Problem.
- Theorem (A&W): This kind of computer can solve NP-complete problems in polynomial time.

# The Toy Model and Physics

- **Toy model**

1. Photo is placed in tt-region and comes out in past
2. Photo is photographed and newly printed photo is **perfect** duplicate

- **More realistic model**

1. Precise microphysical state at tt-region will be transferred to the past (e.g. roughly  $10^{25}$  atoms).
2. The physical state around the tt-region and the laws will determine the function from  $t_1$  to  $t_2$ .
3. For consistency, there must be a fixed-point for this function.
4. If there is a fixed-point, it means that the physical evolution of the state at  $t_1$  reproduces the exact microphysical state at  $t_2$ .

# The Toy Model and Physics

- **Strangeness:**
  - We have no technology for enabling a large state to be preserved for 50 years.
  - If we set up this time-travel system, and we know it works, then we can have very unusual knowledge about 50 years from now.
  - Example: Exact microphysical duplicate, with  $\sim 0$  probability of occurring, will re-emerge at a precise point in time. Any social effort to prevent this will fail.

# Toy Model and General Strangeness

1. You want to simulate a time-travel universe.
2. You construct the physical laws so that there are many tt regions.
3. You pick random initial conditions and then let physics run forward.
4. Intelligent creatures evolve. They build the digital pixel-flipping camera.
5. What happens next .... ?

# Toy Model and General Strangeness II

**Conclusion:** you can't pick physical laws and initial conditions and just run things forward.

If you want to pick this kind of law, you have to either:

1. Let laws be violated whenever no fixed-point exists.
2. Discover the initial conditions that give rise to consistent worlds (by doing a big search).
3. If world is consistent, you still need to **find the fixed point**. This means you need great mathematical resources / ability to create original masterpieces.



# Further reading

- Physics and time travel:

<http://plato.stanford.edu/entries/time-travel-phys>

Using time-travel for computing (Aaronson & Watrous):

<http://arxiv.org/abs/0808.2669>

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<http://ocw.mit.edu>

24.118 Paradox & Infinity  
Spring 2013

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